SOMATIC AND PSYCHOLOGICAL CHARACTERISTICS ASSOCIATED WITH ARTISTIC AND MATHEMATICAL ABILITY IN A UNIVERSITY POPULATION

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DECLARATION

I declare that this thesis for the degree of PhD has been composed solely by myself:

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ABSTRACT

To test the theories of Geschwind and Galaburda (1987) and to examine the somatic and psychological correlates of the artist and the mathematician within the neuropsychological paradigm of lateralisation of brain function, it was decided to used Gordon's Cognitive Laterality Battery and a questionnaire devised from the literature on the personality and cognitive abilities of those in the Arts and the Sciences. Test measures, which for the eye colour variable included reaction time, were analysed using the dichotomised categories derived from the somatic and questionnaire data. As the psychological, neurological, and epidemiological literature suggested that discipline may be something that is decided on the basis of inferiority or superiority of cognitive functioning, both across all tests and, individually, by sub-test profile (including lateralisation), the General Hypothesis predicted that Arts students would score less well than Science students overall. Specific hypotheses referred to individual somatic and psychological characteristics, predicting associations both with each other and with the artist and the mathematician.

Associated areas of investigation included comparisons between sub-groups of Artists, Musicians, Mathematicians, and an extra group of Dyslexics. Rather than use a general population control group (all scores were already expressed as z-scores from a normal population), the Dyslexics were assumed to occupy the furthest end of a continuum continued by the other groups of the University population, until reaching what was predicted would be the opposite cognitive performance pole, that of the Mathematicians. Had it proved possible to meaningfully test artistic savants, these would have been placed at the pole occupied by the Dyslexics; a chapter is included covering what is known concerning the artistic savant, with reference to local individuals studied by the author; in general terms it was predicted that these would demonstrate stronger versions of the disadvantageous characteristics thought to be possessed by normal artists. Another area of investigation was Levy's (1970) study of handedness and differences between Verbal and Performance IQs in a University population; this was semi-replicated using the Appositional and Propositional measures of Gordon's cognitive test; the prediction was that there would be, as in Levy, a greater difference between the A/P scores of left-handers than between the A/P scores of right-handers.

Most of the specific hypotheses were supported: dichotomising variables were identified (all significant at the $p<.05$ level), including ability at mathematics, clumsiness, daydreaming, the ability to draw imaginatively, eye colour, frequent

child illness, and belonging to either an Arts or Science discipline. Certain somatic and psychological characteristics associated with those who were artistic, such as light eyes, clumsiness, child illness, and asthma, while others associated with those who were mathematical, such as dark eyes, allergy, imaginative drawing, and a lack of any clumsiness, child illness, or daydreaming. Reaction time testing of sex and eye colour found significant differences in favour of the male and dark-eyed. The sub-group comparisons supported the predicted poles of the cognitive continuum, including the often-assumed association of Musicians with Mathematicians, and a less often assumed association between Artists and Dyslexics. The Levy semi-replication produced a similar, although non-significant, difference to that found in her experiment. Geschwind and Galaburda's "Pathology of Talent" and speculations concerning immune disorders, eye colour, and dyslexia were supported, although the associations with handedness were weak.

Overall, the General Hypothesis was supported.

A General Discussion used these results to support a view of human individual differences that is not primarily additive but reductive, where rather than "gifted" we are favoured by the foetal, natal, and post-natal environments to retain some of our initially conceived psychoneural potential. Human development is seen by this view as being limited by what remaining neural potential fate or human self-destructiveness has allowed it to develop. The disadvantageous characteristics identified in this research are therefore only some of those which may mark individuals who have suffered the loss of more original potential than others. Finally, a chapter was devoted to a modular metaphor of psychoneural organisation capable of expressing this reductive perspective, and explaining through self-organising Dynamic Neural Devices, **dynads**, the differentiated cognitive profiles of individuals such as the savant, the dyslexic, the artist and the mathematician.

THEME

Tho' much is taken, much abides; and tho'
We are not now that strength which in old days
Moved earth and heaven; that which we are, we are
One equal temper of heroic hearts,
Made weak by time and fate, but strong in will
To strive, to seek, to find, and not to yield

Alfred, Lord Tennyson *Ulysses*, (1842) 1.44

INTRODUCTION

This research was intended to identify somatic and psychological characteristics held in common by highly able individuals in both art and mathematics. It was hoped to establish whether or not there may be a "Pathology of Talent", where high *ability* in certain areas is associated with mental or physical disability. It was thought possible that there may be a grouping of linked characteristics identifiable in both the physically and cognitively very able and the physically and cognitively disabled, but in which isolated talents or "intelligences"are distributed. Deleterious hereditary, uterine, and/or early environmental influences were believed to contribute to such linked characteristics, and in so doing assist in the compensatory development of primarily right hemisphere neural structures, the functions of which appear essential to high performance in both art and mathematics. At all times a continuum conception of ability was maintained, which had the all-round highly able University student at one end, and the dyslexic at the other. General observational research on the idiot savant is reported throughout the thesis; they are cited as the most extreme example of limited ability, beyond the dyslexic, at the furthest end of the ability spectrum from the multitalented. It may be possible to see in them the most intense concentration of the disadvantageous characteristics which may, to a greater or lesser degree, affect all human beings.

This research is indebted to the work of Geschwind and Galaburda, and in particular to their "testosterone theory". The 1985 **Archives of Neurology** three-part "Program for Research" of these two writers invited others to follow the implications of their very speculative, exciting thinking, based on a large body of research by both themselves and their associates, and by many others in the fields of immunology, endocrinology, embryology, animal studies, neurology, and Neuropsychology. Others have, indeed, been inspired, producing notable supporting contributions, such as that of Camilla Benbow and her associates, working with mathematically and verbally precocious children.

The body of work produced by Howard Gardner on the normal childhood development of art, his theory of "Multiple Intelligences", and his clinical neuropsychological studies of the brain-damaged artist have all been influential on this research, as has been the work of Gardner's colleagues, such as Helen Winner, at Harvard's "Project Zero" in providing a general grounding in the Psychology of Art.

Authors such as Lansky and Peterson, H.W. Gordon, Macfarlane-Smith, D.M. Tucker, J. Lindesay, in the areas of handedness, lateralisation of cerebral function and cognitive profile, spatial ability, and the effects of hormone levels on the developmental process in the individual have produced papers and books that are related to this research and have influenced it; from them and many others have been extracted significant elements that have gone toward building up a "portrait" of both the highly able artist and mathematician.

This research provides:

1) some contribution to the ways in which the student artist and mathematician may be identified by a range of associated characteristics;

2) impressionistic, brain-scan, neuropsychological and psychometric data on artistic savants supported by a literature review on such rare individuals;

3) a contribution to explanatory theory concerning the essential nature of artistic and mathematical ability in the cognitively highly functioning, and in those with cognitive disabilities, viewed through the perspective of lateralisation of brain functions;

4) a theoretical contribution to the debate on the nature and organisation of cognitive modules, using the concept of non-linear self-organising dissipative systems.

An Historical False Start

The origins of this research lie in an interest that began in 1984, while writing an undergraduate dissertation in the History of Art Department of the University of Leicester. The course in Psychology being taken by the present writer at the same time naturally led toward an interdisciplinary approach. Having noticed how many precocious artists were to be found in the last decades of the 18th and the first decades of the 19th centuries in Britain, perhaps 20 or so "prodigies", examples of similar present day children were looked for in the psychological literature. This proved quite unhelpful at first: it was not a "popular" area, therefore it had been little researched. Some workers could be identified, such as Howard Gardner, David Feldman, and Sheila Paine. They were to be found in the fields of Neuropsychology, developmental and cognitive psychology, educational psychology, and art education. Later, as a result of seeing the Q.E.D. program **The Foolish Wise Ones**, writing to BBC2 and being put in touch with the psychologists responsible for that remarkable film, the names of Drs. Hermelin and O'Connor could be added to the very limited list of people working in the area.

The historical prodigies were found simply by systematically going through all the biographies and autobiographies on the University bookshelves, looking for those which had a record of the artist's childhood. There may have been several reasons why there seemed to be so many prodigies at the end of the 18th century:

1) The influence on the perspective of parents and teachers of the publication of J-J. Rousseau's book **Emile** (1762): children were now seen as having developmental stages which any teacher had to recognise and for which allowance had to be made, and, more importantly, they were seen as having innate talents that could be brought out by a sensitive teacher. Pestalozzi and Froebel in Europe carried Rousseau's ideas into practice in schools.

2) The rise of Romanticism tended to concentrate the minds of authors on origins and the idea of an ultimate first state of innocence; the Garden of Eden and the noble savage figured large in Romantic literature. In each individual's personal history the child was seen as occupying an equivalent position, that of the supernaturally talented innocent (The child was "supernatural" because, being so much closer to God in his or her innocence, so little touched by the taint of human society, they were in closer contact with the source of all genius). It is in this conception that one finds the origins of the constantly repeated 19th century formulation: "Ontogeny recapitulates Phylogeny". It is likely that biographers turned their attentions rather more than had been the case to their subjects' childhood times, and in particular were eager to find any signs of innate genius, any predictive characteristics of the fame that was to follow. In this, they were returning to a way of regarding artists, in particular, that had been popularised in the 16th century by Vasari, in his **Lives** (1550).

3) In the 1930's, Kris and Kurz[1] identified a tendency in the biographers of artists to use biographical formulae (which ultimately derive from antique sources), inserting them into gaps in their subjects' childhood annals. Such formulae may be found in biographies all through history. Thus child artists always seem to be shepherd boys, drawing perfect circles on stones or in sand, or are forever correcting master painters when only five years old, or always seem to be forcing their masters to give up painting because of their precocious brilliance. Tales such as these have been told about hundreds of different artists, from Giotto and Leonardo to Segantini and Picasso. The writers of those 18th and 19th century biographies were obviously not immune to this mythicising tendency.

When all the above was taken into consideration, it nevertheless still remained possible to detect factual information which could be disentangled from clearly unreliable records, details that an author had included in a sometimes wild and woolly account that found echoes in many of the other biographies, details incidental to the fabulous tales and *not* dependent on them.

[1]Kris, E., and Kurz, O., **Legend, Myth, and Magic in the Image of the Artist: A Historical Experiment**, New Haven and London, Yale University Press, 1979.

Together with this, the psychological literature had given a more reliable factual foundation, a set of case studies of recent precocious artists possible to compare with the historical prodigies, as well as a few studies of the personality characteristics most often found in the mature artist. Although these elusive, part-fictive ghosts of the past seemed impossible to quantify for accurate study, they *did* contain elements of significant fact:

1) A high proportion were characterised as blond, blue-eyed and very handsome or beautiful (A generalisation gleaned from biographies of artists dating from the late 18th and early 19th centuries, so less likely to be tainted with any later Aryan supremacist theories).

2) A significant number exhibited gymnastic and sporting abilities.

3) They exhibited musical, dramatic, and/or mathematical abilities.

4) It was frequently remarked that they appeared to be hyperactive and, as a consequence, troublesome to their parents.

5) Most appeared to store detailed visual images for later use, sometimes years later.

6) An unusual number appeared to have speech disabilities or learning difficulties.

7) Very often their fathers were craftsmen, often metalworkers, gold- or silversmiths (see Havelock Ellis, 1904).

8) A disproportionate number appeared to be ambidextrous, while some could tentatively be identified as left-handed.

9) Early illness often seemed to be of an allergic variety, possibly indicating immune system disturbance.

10) All had what currently approved stage theories of both artistic and general cognitive child development would say was an impossible extremely early understanding of perspective, three-dimensional volume, texture gradients, object occultation, and concealed object continuity. Art works which have endured to the present day, lovingly dated by doting mothers, are evidence of this.

The superior physical characteristics and abilities mentioned may be thought to be similar to that common good health and vigour discovered by Terman in his early 20th century longitudinal survey of gifted children,[2] a vigour deriving more from the predominantly middle-class, well-fed nature of Terman's sample than any

[2] Terman, L.M., **Genetic studies of Genius, Vol. I. Mental and physical traits of a thousand gifted children**, Stanford, CA: Stanford University Press, 1925.

characteristic associated with giftedness; indeed, both precocious artists and mathematicians came from widely varying social and economic backgrounds: they were the children of artists, carpenters, barbers, the landed gentry, teachers, engineers, and poor farm workers. Some could be called gifted, having a wide range of competencies apart from art or math, while others were clearly mono-talented.[3] Physical beauty has often been noted in some handicapped groups, such as the autistic; Rett's syndrome girls, too, show an elfin beauty, but have little intelligence after three years or so.[4] There seems no necessary link between a handsome face and form and IQ, nor a link between IQ and outstanding ability in art or math.[5] Artistic prodigies identified include Sir Thomas Lawrence, John Everett Millais, Sir Edwin Landseer, John Opie, J.M.W. Turner, Angelica Kaufmann, Fuseli, George Moreland, Gustave Dore, Aubrey Beardsley, Toulouse Lautrec, and Pablo Picasso.

A theoretical basis for the research developed which conjoined both modular theories of intelligence and the "testosterone" theory of the late Norman Geschwind and of Albert Galaburda. It seemed that only by viewing savants, the dyslexic, and, indeed, **everyone**, as concatenations of ability modules differentially developing at varying rates through the psychoneural effects of prenatal pathology as well as postnatal insult could the differential and sometimes anomalous nature of both their abilities and disabilities be explained. A hereditary component in the genesis of particular talents and linked pathologies had to be presumed, and so a polygene was postulated which manifested in the phenotype at certain physiological and psychoneural stress thresholds. Manifestly, the aetiology of the pathology of talent was always going to be a complex and difficult one to trace. Nevertheless, talent in any area is derived from multiple sources, genetic, environmental, psychological, biological, neurological, sociological, and educational; anyone studying the area of ability or talent must be prepared to face such complexity with whatever courage they are able to muster.

The mathematically skilled were chosen as the traditional "opposed pole" to artists, as famously conceived by C. P. Snow in his "Two Cultures". It was hoped in the earliest form of this research to demonstrate that the so-called "abyss" between the two was illusory, and that the differences between them, if any, were small, deriving from social forces, perhaps. As the research developed, however, it began to be obvious that such egalitarian ideals were not sustainable, with somatic and pathologic influences growing in importance.

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[3] Fallone, A.R., Artistic Prodigies: Can Current Child Development Theories Explain Them? Unpublished Undergraduate Dissertation, University of Leicester, June, 1985.

[4] Rett, A., Uber ein eigonertiges hirnatrophisches Syndrom bei Hyperammonamie im Kindersalter, **Wein Med. Wochenschr.**, 116, 723-738, 1966.

[5] Cox, C.M., **The Early Mental Traits of 300 Geniuses; Volume II of Genetic Studies of Genius**, Stanford University Press, California, 1926. One of Terman's team, she found that only soldiers of genius had lower IQs than the artists of genius in her study.

PLAN OF THE THESIS

The following chapters will show:

1) the evidence found in the literature of several disciplines to support choosing the categories and variables used in the research;

2) Research on the artistic savant, including impressionistic data, psychometric and neuropsychological measurements, together with Nuclear Magnetic Resonance Imaging scans on one Edinburgh savant;

3) a section on modularity theory, with application to dyslexics, savants and normals;

4) the results of the quantitative research carried out, a Summary, and a Discussion;

5) finally, there will be theory of self-organising neural modularity to help explain how talents and disabilities may coexist in any individual, be they University student, dyslexic, or savant.

GENERAL HYPOTHESIS

Given the above thesis, it follows that, in addition to the known disadvantageous factors which influence cognitive ability, there may be others which, if not in themselves hostile to human functioning, act as "flags" or markers for other influences which co-occur with them and serve to differentially reduce cognitive ability; these produce different clusters of characteristics which may serve to identify the artist and the scientist.

ARTISTS, MATHEMATICIANS AND "THE LEFT HAND PATHOLOGY"

The late Norman Geschwind and Albert M. Galaburda published a three-part article on **Cerebral Lateralisation** in the May, June, and July, 1985 issues of ***Archives of Neurology*** which summarised an enormous quantity of research carried out by both themselves and many other workers in allied fields, in an attempt to generate further research. Drawing on a wealth of evidence, mixed with not a little daring speculation, they theorised concerning a web work of interconnections between characteristics and skills of individuals in both normal developmental areas and those suffering under the influence of some pathology. In Geschwind and Galaburda's review they pointed out that researchers have found that, for example, left-handedness is more common in the young European and North American, in the so-called "primary" homosexual, perhaps in AIDS sufferers, too, together with outstanding athletes, artists, architects, engineers, and mathematicians.

There is, they say, a raised incidence of left-handedness in autistic, dyslexic, hyperlexic, hyperactive, and monozygotic twin children, together with the first degree relatives of twins. Individuals who suffer motion sickness, migraine headaches, hare-lip and cleft palate, and have fair or prematurely grey hair are more likely to be left-handed, as well, while the relatives of individuals with hare lips are twice as likely to be left-handed as right-handed. Sufferers from strabismus and scoliosis, Klinefelter males, and the daughters of mothers given diethylstilbestrol in pregnancy have a higher incidence of left-handedness. Males born in the six months beginning with September are more likely to be left-handed, while left-handed males are more likely to stutter. Curiously, left-handed mothers are more likely to produce left-handed children than are left-handed fathers, pointing to the mother's contribution in this area being more important, and that, indeed, handedness **may** be predictable from the maternal grandparents.

Some support has been found for the testosterone theory: from Coren, Searleman and Porac (1986), who found delayed rates of maturation in both sexes associated with an increased incidence of left-handedness; Smith (1987), who reported that significantly more urticaria and eczema patients attending an allergy clinic were left-handed than right-handed ($p<.0005$); Lindesay (1987) identified a 'left-shift' in the handedness of homosexual men attending a venerology clinic and a significant increased frequency of childhood alteration of the preferred hand; Nass, Baker, Speiser *et al* (1987) found that girls with congenital adrenal hyperplasia (which results in higher testosterone levels) are more left-biased than their normal sisters; Searleman, Cunningham and Goodwin (1988), who observed that a positive history of familial sinistrality was significantly more likely to occur in mildly mentally retarded individuals (Chi-sq.=5.78, $p<.02$); Searleman and Fugagli (1987), who report a raised incidence of left-handedness in patients with Crohn's disease and ulcerative colitis; Wexler, Mason and Giller tested a group of affective disorder patients' laterality with a dichotic listening task and their serum levels of testosterone, finding a positive association between both higher and lower testosterone levels, severity of disorder and responsivity to words (1989); Lucas, Rosenstein and Bigler (1989) reported an increased prevalence of left-handedness among 238 mentally retarded individuals with language deficits, twice that among the general population, the effect being stronger for females; Casey and Nuttall (1990) describe differences between anomalously dominant [AD] women and normal dominance women on a test of sex role identity, with AD women having a higher masculine sex role score; Temple (1990) reported on field of University study, handedness and immune disorders, finding that mathematical academics were significantly more susceptible to rare immune disorders and four times more likely than verbal academics to have suffered from a language related problem in childhood, while pure mathematicians are far less likely to be left-handed than applied mathematicians; Chen and Leviton (1990) record that the risk to children of mothers with both asthma and migraine was greater for developing asthma or eczema in their first seven years than for children whose mothers had either or neither, indicating the two diseases were related; Dellatolas, Annesi, Jallon*et al* (1990) consider epidemiological data in two large samples on stuttering, handedness and allergic disorders, recording that there was a higher degree of stuttering among left-handers, while left-handedness and allergic disorders were significantly related (N=9591 males, $p<.001$); Becker, Bass, Dew, *et al* (1992) report an association between handedness and allergy and a significantly raised level of left-handedness among a sample of gay/bisexual men (roughly half with HIV+).[6] Very recent research

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[6] Benbow, C.P., Physiological Correlates of Extreme Intellectual Precocity, **Neuropsychologia**,1986; Coren, S., Searleman, A., and Porac, C., Rate of Physical Maturation and Handedness, **Developmental Neuropsychology**, 2(1), pp. 17-23, 1986; Smith, J., Left-handedness: its association with allergic disease, **Neuropsychologia**, Vol. 25, No. 4, pp. 665-674, 1987; Lindesay, J., Laterality Shift in Homosexual Men, **Neuropsychologia**, 1987; Nass, R., Baker, S., Speiser, P., Virdis, R., Balsamo, A., Cacciari, E., Loche, A., Dumic, M., and New, M., Hormones and handedness: Left-hand bias in female congenital adrenal hyperplasia patients, **Neurology**, 37, April, pp. 711-715, 1987; Searleman, A., and Fugagli, A., Suspected autoimmune disorders and left-handedness: evidence from individuals with diabetes, Crohn's disease and ulcerative colitis, **Neuropsychologia**, 25(2), 367-374, 1987; Searleman, A., Cunningham, T.F., and Goodwin, W., Association Between Familial Sinstrality and Pathological Left-Handedness: A Comparison of Mentally Retarded and Nonretarded Subjects, **Journal of Clinical and Experimental Neuropsychology**, Vol. 10, No. 2, pp. 132-138, 1988; Wexler, B.E., Mason, J.W., and Giller, E.L., Possible Subtypes of Affective Disorder Suggested by Differences in Cerebral Laterality and Testosterone: A Preliminary Report, **Archives of General Psychiatry**, Vol. 46, May, pp. 429-433, 1989; Lucas, J.A., Rosenstein, L.D., and Bigler, E.D., Handedness and language among the mentally retarded: implications for the model of pathological left-handedness and gender differences in hemispheric specialisation, **Neuropsychologia**, Vol. 27, No. 5, pp. 713-723, 1989; Casey, M.B., Nuttall, R.L., Differences in feminine and masculine characteristics in women as a function of handedness: support for the Geschwind/Galaburda theory of brain organisation, **Neuropsychologia**, Vol. 28, No. 7, pp. 749-754, 1990; Temple, C.M., Academic discipline, handedness and immune disorders, **Neuropsychologia**, Vol. 28, No. 3, pp. 303-308, 1990; Chen, T.C., Leviton, A., Asthma and Eczema in Children Born to Women With Migraine, **Archives of Neurology**, Vol. 47, Nov., pp. 1227-1230, 1990; Dellatolas, G., Annesi, I., Jallon, P., Chavance, M., and Lellouch, J., An Epidemiological Reconsideration of the Geschwind-

(published in ***Science***) by Professor LeVay of the Salk Institute, San Diego, California has found that the interstitial nucleus of the anterior hypothalamus, a locus for heterosexual urges, is half the size in homosexual than in heterosexual men, the same size as in women;[7] other research published in the ***Proceedings of the National Academy of Sciences*** (1992) by Drs. Laura Allen and Roger Gorski of the University of California Medical School at Los Angeles indicates that the anterior commissure (a nerve bundle connecting the two halves of the cerebral cortex) in homosexual men is 34% larger than in heterosexual men, once more very little different in size to that of women.[8] Such differences in brain structures, possibly due to differing levels of foetal hormones, may well produce corresponding differences in behaviour and cognition.

Other authors have been forced to take Geschwind and Galaburda's theories into account but have neither confirmed or disproved them.[9] Still others have found against their theories: Salcedo and Spiegler *et al* (1985) viewed their own finding of 14.8% of left-handers among 54 sufferers from lupus erythematosus as non-significant; Messinger, Messinger and Graham (1988) tested Geschwind and Galaburda's hypothesis of an association between migraine and left-handedness with 437 patients at the Headache Research Foundation in Boston, finding no significant associations; Barr, Jaffe *et al* (1989) looked at the regional distribution of cerebral arteriovenous malformations (AVMs) in 112 New York patients, finding no real support for Geschwind and Galaburda's prediction that more AVMs would be found in male left hemispheres-rather, they found that it was females who showed this pattern, males showing the reverse, with nondextrals showing more AVMs in both frontal regions than anywhere else; McKeever and Rich (1990) report that in a sample of 3080 students they found no real association of left-handedness with immune disorders; Betancur and Velez *et al* (1990) found similarly (in an experimental group of 325) that there was no association of allergies and left-handedness, although there *was* such a tendency *before* puberty; Chavance and Dellatolas *et al* (1990) point to an information bias as the reason for previous associations found between diseases such as lupus, type 1 diabetes, Grave's disease or migraine-in 737 French patients suffering from such illnesses they found no association with left-handedness; Bryden, McManus and Steenhuis (1991) report no association between such diseases as asthma, hay fever, eczema, drug or food allergies, rheumatoid arthritis, migraine, or persistent headaches and left-

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Galaburda Theory of Cerebral Lateralisation, **Archives of Neurology**, Vol. 47, July, pp. 778-782, 1990; Becker, J.T., Bass, S.M., Dew, M.A., Kingsley, L., Selnes, O.A., and Sheridan, K., Hand preference, immune disorder and cognitive function among gay/bisexual men: the Multicenter AIDS Cohort Study (MACS), **Neuropsychologia**, Vol. 30, No. 3, pp. 229-235, 1992.

7 McGourty, C., Homosexuality 'may be due to differences in the brain', **Daily Telegraph**, 30/8/1991 and Anon., 'Biological link' in brains of gay men, **The Independent**, 30/8/1991.

8 Reed, C., Homosexuals are 'born not made', **The Guardian**, 3/8/1992 and Reeves, P., Scientists find another difference in brains of gays, **The Independent**, 3/8/1992.

9 Gordon, H.W., and Lee, P.A., A Relationship Between Gonadotropins and Visuospatial Function, **Neuropsychologia**, 1986.

handedness in 743 undergraduates; Satz, Miller and Selnes *et al* (1991) failed to find any link between homosexuality, handedness and autoimmune disorder in a sample of 993 from the Multicenter AIDS Cohort Study, Los Angeles; Marchant-Haycock, McManus and Wilson (1991) report on a sample of 791 homosexuals and normals tested for association between handedness and vulnerability to AIDS, migraine, dyslexia and stuttering, finding that there was no such association as that expected by Geschwind and Galaburda; Stanton, Feehan, Silva and Sears (1991) found no association of handedness with allergies in over 1000 New Zealand children; Gilger, Pennington, Green *et al* (1992) looked at reading disability, immune disorders and non-right-handedness in a sample of 1731 in family and twin studies, finding no robust associations between these three characteristics, although they found an elevation of both autoimmune and allergic disorders in their dyslexic subjects.[10]

Nevertheless, Geschwind and Galaburda say that atopic disorders such as eczema and hay fever, and asthma are more common in pre-pubertal males and stutterers, such children seemingly more resistant to parasitic infections, while immune disorders are more common in post-pubertal females, Klinefelter males, left-handed dyslexics and their families, together with fair- and prematurely grey-haired individuals. Those with immune disorders have a high rate of lymphoid malignancies, as well. All these associated pathologies and characteristics would have a shared association with *spatial ability*, and therefore with artistic ability, too. Left-handedness is associated with high spatial ability, and so those individuals afflicted in the previously mentioned ways, and in addition being more likely to demonstrate left hand dominance, might be expected to show heightened skills in

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10 Salcedo, J.R., Spiegler, B.J., Gibson, E., Magilavy, <u>The autoimmune disease systemic lupus erythematosus is not associated with left-handedness,</u> (Note) **Cortex**, 21, pp. 645-647, 1985; Messinger, H.B., Messinger, M.I., and Graham, J.R., <u>Migraine and left-handedness: Is there a connection?</u> **Cephalalgia**, 8, pp. 237-244, 1988; Barr, W.B., Jaffe, J., Wasserstein, J., Michelson, W.J., Stein, B.M., <u>Regional Distribution of Cerebral Arteriovenous Malformations: Interactions With Sex and Handedness,</u> **Archives of Neurology,** Vol. 46, April, pp. 410-412, 1989; McKeever, W.F., and Rich, D.A., <u>Left-handedness and immune disorders,</u> **Cortex**, 26, pp. 33-40, 1990; Betancur, C., Velez, A., Cabanieu, G., Le Moal, M., Neveu, P. J., <u>Association between left-handedness and allergy: a reappraisal,</u> **Neuropsychologia**, Vol. 28, No. 2, pp. 223-227, 1990; Chavance, M., Dellatolas, G., Bousser, M.G., Amor, B., Grardel, B., Kahan, A., Kahn, M.F., Le Floch, J.P., and Tchobroutsky, <u>Handedness, Immune disorders and information bias,</u> **Neuropsychologia**, Vol. 28, No. 5, pp. 429-441, 1990; Bryden, M.P., McManus, I.C., and Steenhuis, R.E., <u>Handedness is not related to self-reported disease incidence,</u> **Cortex**, 27, pp. 605-611, 1991; Satz, P., Miller, E.N., Selnes, O., Van Gorp, W., D'Elia, L.F., Visscher, B., <u>Hand preference in homosexual men,</u> **Cortex**, 27, pp. 295-306, 1991; Marchant-Haycox, S.E., McManus, I.C., and Wilson, G.D., <u>Left-handedness, homosexuality, HIV infection and AIDS,</u> **Cortex**, 27, pp. 49-56, 1991; Stanton, W.R., Feehan, M., Silva, P.A., and Sears, M.R., <u>(Note) Handedness and allergic disorders in a New Zealand cohort,</u> **Cortex**, 27, pp. 131-135, 1991; Gilger, J.W., Pennington, B.F., Green, P., Smith, S.M., and Smith, S., <u>Reading disability, immune disorders and non-right-handedness: twin and family studies of their relations,</u> **Neuropsychologia**, Vol. 30, No. 3, pp. 209-227, 1992, and earlier Pennington, B.F., Smith, S.D., Kimberling, W.J., Green, P.A., Haith, M.M., <u>Left-Handedness and Immune Disorders in Familial Dyslexics,</u> pp. 634-639, **Archives of Neurology,** Vol. 44, June, 1987.

the areas of art, mathematics, and architecture. It is truly the pathology of talent, where islands of superiority rise from a sea of deficit.

Testosterone And The Development Of The Brain

Geschwind and Galaburda theorise that the underlying cause of this complex set of associations, these interconnected abilities and deficits is that some children have been subjected to a uterine environment higher than normal in androgens, specifically testosterone, which they claim retards the development of some areas of the left hemisphere and such areas associated verbal-sequential abilities. This allows not only other areas of the right hemisphere with their associated visual-spatial functions to dominate, but also adjacent areas of the left hemisphere. A locus on chromosome-15 has been speculated to control not only the production of a protein essential for immune responsiveness, but also testicular development **and** a predisposition to dyslexia.[11]

Both male and female sex hormones exist in different balances within us all; for instance, when it is said that late puberty females have a higher spatial ability[12] it is claimed by followers of the testosterone theory that it is because they have been exposed to a high testosterone body environment for longer than females with an early puberty and the consequent raising of the latter's levels of oestrogen and progesterone.[13] Similarly, some children born **late** may have been exposed for an extended period to a high testosterone uterine environment and so have had a slowing-down of the development of some left-hemisphere areas.[14] Geschwind and Galaburda say: "...high talents may exist as a result of compensatory enlargement of

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[11] Pennington and Smith, et al, in <u>Developmental continuities and discontinuities in a form of familial dyslexia</u>, in Emde, R.N., and Harmon, R.J., { eds. }, **Continuities and Discontinuities in Development**, N.Y., Plenum Pub., pp. 123-151, 1984, studying extended families of dyslexics for genetic linkages of dyslexia with chromosome15 centromeric and short-arm heteromorphisms, found linkage to chromosome 15 markers in some families and not in others. They argue from this that the causes of dyslexia may be heterogeneous.

[12] Waber, D.P., <u>Sex differences in mental abilities, hemispheric lateralisation, and rate of physical growth in adolescence</u>, pp.29-38, **Developmental Psychology**, 13, 1977.

[13] Androgens are produced in the normal female by the adrenal glands. Overproduction in some females leads to masculine characteristics, such as excessive facial and body hair. The growth of "beards" by older women results more from depressed levels of female hormones after the menopause than any raised level of androgens.

[14] In females, this may be due to some hormonal imbalance in the mother, or to the mother having been given male hormones during pregnancy to forestall a miscarriage, while in males the uterine environment is rich in gonad-produced androgens, a within-body production which falls away soon after birth, not to rise again to such levels until puberty.

other cortical regions."[15] It is therefore possible that able artists have either been overdue at birth or, in the case of females, have had a late onset of puberty, and in the case of males an early onset of puberty.

Although the data of Gordon and Lee (1986) on levels of LH and FSH in males and females with regard to cognitive abilities do not confirm or deny the theories of Geschwind and Galaburda, they serve to shift the attention away from *prenatal* effects of sex hormones to their *contemporary* effect in either gender. It appears from their results that the effect of such hormones on behaviour is stronger for males than for females. Males, then should show greater right hemisphere abilities than females, who should in turn be more symmetrically able.

The Immune System, Puberty, And The Shorter Life Of The Baseball Southpaw

The reason why pre-pubertal males are more likely to suffer from allergies is seen by Geschwind and Galaburda as that, after leaving the high testosterone foetal environment, males have a relatively low testosterone body environment until the onset of puberty; at 12 or 13, testosterone suppresses the effect of the thymus gland, protecting the male from the effects of a highly-geared immune system, the same sort of highly-geared immune system which is found in females *after* puberty. That is when the autoimmune diseases peculiar to females begin to make themselves felt, such as lupus erythmatosus and myasthenia gravis, as well as those atopic disorders such as eczema, asthma and hay fever suffered intensely before puberty by males. For this reason as well, after puberty females have a greater tendency than males to reject skin grafts, although they are less likely to die of infections. With increasing age, the effect of testosterone in the male declines and so once more they become more susceptible to the autoimmune diseases. Greying of the hair may be a sign of this, as the immune system attacks misidentified pigment.[16] Although pure speculation, it may be that the raised strength of the older male's immune system and the reduced strength of the female immune system after menopause could have something to do with the difference in the overall life expectancy of males and females, females living on average 7 or 8 years longer than males (70 to 77/78).

Such alterations in immune system strengths seem to make little difference to resistance to disease or infection, the major task of the immune system all through life. If that were the case, it may be expected that the usual life expectancies would be reversed. It would seem that in several ways the immune system can be a greater

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[15] p.521, Geschwind, N., and Galaburda, A.M., Cerebral Lateralization: Biological Mechanisms, Associations, and Pathology: (2) A Hypothesis and a Program for Research, pp.521-562, **Archives of Neurology**, Vol.42, June, 1985.

[16] Studies have shown that the male superiority in spatial tests declines after middle age; this may or may not be linked with the immune system and testosterone level changes at that period: in Schwartz, D.W., and Karp, S.A., Field dependence in a geriatric population, **Perceptual and Motor Skills**, 24, 1967, pp.495-504.

enemy of the individual than anything else, a veritable "Fifth Column".[17] Research published in ***Nature*** by the Canadian psychologist, Dr Stanley Coren, aimed to further investigate Porac and Coren's earlier findings that while 13% of 20-year-olds are left-handed, this figure decreases to 5% of 50-year-olds, and finally to virtually no 80-year-olds. Dr Coren and Dr Diane Halpern looked through the US Baseball Encyclopaedia to check players' throwing and batting hands, and dates of birth and death. They found that the average age of death for 1472 right-handers was 64.64 years, while the 236 left-handers lived to the lesser mean age of 63.97 years. No differences existed in death rates between dextrals and sinistrals until the age of 33, then the left-handers begin to "fade away".[18] Such are the assorted pathologies associated with left-handedness that these alone might be thought to account for the lower life expectancy of sinistrals. However, other factors may be involved, such as the lessened contemporary social pressure on the young left-hander to change hands, as compared with that exerted on the older citizen in their younger days. As a consequence there will be a greater number of left-handers in the younger age range. Another factor not apparently considered by Dr Coren in his earlier research on the general population is that there is a gender differential in left-handedness: males are both more likely to die younger than females and to be left-handed, therefore the fewer numbers of sinistrals in the older age groups may be accounted for by the winnowing out of the left-handed males, leaving the predominantly right-handed female elder citizens. This would not apply to the baseball data, as there are very few female pitchers, of any age! Left-handedness seems to bring with it many disadvantageous fellow-travellers.

The Neural Crest, Hair And Eye Colour, And Migrating Neurones

Geschwind and Galaburda say that the effects of testosterone may depend on tissue sensitivity as well as the level of the free hormone; its actions vary from location to location within the brain, with testosterone receptors having recently been found in the association cortex. However, the effect of raised levels of the hormone may be seen in very early uterine life, affecting the symmetry of the migration of neurones from the neural crest of the foetus, the development and products of which they believe to be affected by the uterine level of sex steroids. The neural crest is an area of the developing foetus from which derive many of the structures of the head; it plays a part in the formation of the autonomic ganglia, cranial nerve ganglia, parts of the forebrain, the connective tissue of the thymus gland (which can affect the development of the teeth-children with learning deficiencies very often have distorted or rotten teeth), the skin and bones of the face, and nearly every pigmented

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17 If a connection could be proved between a raised incidence of lymphoid or other malignancies and post-middle age in males, then it may be that a too-powerful immune system is the cause of some types of cancer.

18 p. 206, Coren, S., **The Left-Hander Syndrome: The Causes and Consequences of Left-Handedness,** John Murray, London, 1992.

cell in the body. Lack of melanin-bearing cells in the pigment epithelium of the retina causes the individual to possess blue eyes.

Melanin-bearing cells may be necessary to act as guides for migrating optic nerve fibres, say Geschwind and Galaburda. Children with learning deficiencies very often have eye problems, cataracts or myopia, and, as Benbow has found, mathematical "prodigies" very often have myopia. It would be interesting to study the children in her Johns Hopkins University accelerated mathematical tuition classes, or at Iowa State University, for raised levels of blond or fair hair and blue eyes. Schacter *et al* confirmed Geschwind and Galaburda's predictions concerning the association of learning disabilities, left-handedness, and gender with hair colour, subjects with afflictions such as dyslexia being nearly twice as likely to be blond compared with individuals without learning disabilities.[19] It seems likely that this guidance system operates in other areas. Pigmented cell guides which mis-direct neurones when markers for their destinations (apparently the responsibility of the immune system) are disturbed, perhaps by altered hormonal conditions in the uterus, could be compared with Wild-West scouts who have been led astray, when their wagon-trains may find themselves in the wrong part of the country, or perhaps have run into an Indian war-party and gone no further. This may account for hare-lips and cleft palates, for lack of pigmentation in hair and skin, for chaotic cytostructures in the left hemisphere in dyslexics, in short, for most of the pathologies discussed earlier. Blondes have been found to be more likely to have hare lips, while early grey hair is associated with autoimmune thyroid disorder, and possibly other immune diseases, together with left-handedness, say Geschwind and Galaburda (1987).

Richard Wawro, the autistic and severely handicapped Edinburgh artist, has had cataracts, severe myopia, light reddish hair and blue eyes, and badly deformed and rotten teeth. The famous left-handed, highly precocious Swiss artist, Fuseli, had hair that went pure white in his mid-twenties, while myopia and cataracts plagued many artists, including Degas and Monet, although it is not certain exactly when these disabilities first manifested themselves.[20] Curiously, Havelock Ellis' 1904 **A Study of British Genius** found that, classified by an index of pigmentation, men of science

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[19] Schacter, S.C., Ransil, B.J., and Geschwind, N., Associations of Handedness with Hair Colour and Learning Disabilities, pp.269-276, **Neuropsychologia**, Vol.25, No.1b, 1987.

[20] The purist Impressionists, such as Monet and Sisley, and the early Renoir, had an almost autistic obsession with recording exactly what they saw. All linguistic/symbolic or narrative elements were ruthlessly purged from their work. It was as though they had forgone any left hemisphere functions completely. Conversely, Manet's notoriously poor grasp of composition, and his presentation of the elements of his subject matter as connected more by meaning and significance than by any unified scheme of perspective or overall structure, could perhaps indicate some sort of failure of right hemisphere functioning. Manet died of syphilis; it may or may not have been congenital, or have damaged his brain.

and painters, sculptors and architects tended to be fair and blue-eyed, whereas men and women of letters and divines tended to be dark.[21]

It has often been pointed out how many of the best male and female tennis players have been blond or red-haired, blue-eyed left-handers or double-handers (Boris Becker, Bjorn Borg, Steffi Graf, Chris Evert, Martina Navratilova, Rod Laver, Lew Hoad,Tony Roche, Anne Jones, Stefan Edberg, John MacEnroe, Monica Seles, and so on.). Annett records the incidences of left-handedness in tennis players at Wimbledon from 1947 to 1978, which show that of the male singles players (128), 15.6% were left-handers, and of the females (96), 9.4%. Champions (m-33) were 15.1% and (f-33) 6.1%, respectively. The proportions of left-handed male players and champions were almost twice as high as the 8.1% reporting left-handed use of a tennis racquet in her own questionnaire (1970). Further, she quotes computer rankings of tennis professionals up to 1982, which show that 30% of the top ten were left-handers, 14% of those down to number 100, and only 6% of all those down to number 360. There is a statistically significant excess of left-handers in the top half of these rankings as compared with the bottom half (Chi Square=12.60, df=1, p<.001).[22] Not so far having attracted comment are the high numbers of red- or fair-haired snooker champions, a sport where centimetre-perfect spatial judgement, very fine motor-skills, and the ability to visualise the future ball pattern on the table are essential talents (Steve Davis, "Hurricane" Higgins, World Champion Stephen Hendry, and others; even the dark-haired John Parrot and Jimmy "Whirlwind" White have blue eyes).

Eye colour is a marker which has been used many times in the past by psychologists who wished to find associated factors or characteristics with various physiological, cognitive or behavioural phenomena. As it is such an easily seen physical trait it has an obvious attraction for researchers. Indeed, such associations have been observed: pulse rate, pulse pressure, respiration rate, galvanic skin response, and body temperature are some of the physiological variants with eye colour,[23] [24] together with magnitude of pupillary dilation,[25] oculocardiac reflex,[26] and resistance to the damaging effects of industrial noise.[27] Usually, it is the light-eyed individual who is

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[21] Ellis, H., **A Study of British Genius**, London: Hurst and Blackett, 1904.

[22] p.383, Annett, M., **Left, Right, Hand and Brain: The Right Shift Theory**, London: Erlbaum, 1985.

[23] Kent, I., Human Iris Pigmentation: 1. A concept of individual reactivity with implications in health and disease, **Canadian Psychiatry Association Journal**,1: 99-104,1956a.

[24] Markle, A., Eye colour and responsiveness to arousing stimuli, **Perceptual and Motor Skills**, 43: 127-133, 1976.

[25] Gambill, H.D., Ogle, K.N., and Kearns, T.P., Mydriatic effect of 4 drugs determined with pupillograph, **Archives of Opthalmology**, 77: 740-746, 1967.

[26] Fry, E.N.S., and Hall-Parker, J.B., Eye hue and the oculocardiac reflex, **British Journal of Opthalmology**, 62: 116-117, 1978.

[27] McFadden, D., and Wightman, F., Audition: Some Relations Between Normal and Pathological Hearing, **Annual Review of Psychology**, 34: 95-128, 1983.

found to suffer by comparison with the dark-eyed; for instance, blue-eyed people have lower tactile thresholds on the cornea, and report more pain from wearing contact lenses, than do people with brown eyes;[28 29] however, brown-eyed people are apparently much more likely to request a local analgesic for dental extraction than blue-eyed people.[30] Certain pathologies are more associated with light-eyed people: malignant melanoma are more likely to be developed by light-eyed, light-haired individuals,[31] while patients with light coloured irises are more likely to suffer from Idiopathic Dystonic Syndromes, involuntary movements of the sort found in Huntington's and Parkinson's disease.[32] It appears that patients who suffer from a variety of brittle bone disease, clearly derived from a calcium disorder, are known for their light coloured eyes.[33] Neural Crest Syndrome is characterised by autonomic dysfunction manifested in pupil abnormalities and pain perception, and by the absence of sweating; all reported cases are blond, blue-eyed and fair-skinned.[34] As some sort of balance, it has been observed in autopsies that schizophrenics produce increased amounts of melanin pigment;[35] the implication of this is that albinos, who are characterised by decreased melanin production, are protected from schizophrenia.[36] Sufferers from phenylketonuria are frequently light-eyed,[37] while autistics have been observed by Kastein (1966) to be predominantly light-haired and light-eyed.[38] Prader-Willi syndrome has recently been recognised as marked by light coloured hair and eyes.[39] Gary and Glover[40] carried on the work of Dr Morgan Worthy[41] into eye colour and human behaviour; they supported the findings of

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[28] Millodot, M., Do blue-eyed people have more sensitive corneas than brown-eyed people? **Nature**, 255: 151-152, 1975.

[29] Tota, G., and La Marca, F., Correlations between corneal sensitivity and iris colour, **Atti della Fondazione Giorgio Ronchi,** Vol. 37 { 1 }: 59-69, 1982.

[30] Sutton, P.R.N., Association between Colour of the Iris of the Eye and Reaction to Dental Pain, **Nature,** Vol. 184, 122, July 11th, 1959.

[31] Gellin, G.A., Kopf, A.W., and Garfinkel, L., Malignant Melanoma: A Controlled Study of Possible Associated Factors, **Archives of Dermatology**, Vol. 99, 43-48, 1969.

[32] Korein, J., Iris Pigmentation <Melanin> in Idiopathic Dystonic Syndromes Including Torticollis, **Annals of Neurology,** Vol. 10, No. 1: 53-55, 1981.

[33] Ferguson, R. <Nurse>, personal communication.

[34] Brown, J.W., and Podosin, R., A syndrome of the neural crest, **Archives of Neurology**, 15: 294-301,1966.

[35] Greiner, A.C., and Nicolson, G.A., Schizophrenia-melanosis, **Lancet, ii:** 1165,1965.

[36] One case of a schizophrenic albino has been found, however: Pollack, M.H., and Manschreck, T.C., Oculocutaneous Albinism and Schizophrenia, **Biological Psychology,** 21: 830-833, 1986.

[37] Berg, J.M., and Stern, J., Iris Colour in Phenylketonuria, **Annals of Human Genetics,** 22: 370-372, 1958.

[38] Kastein, S., and Trace, B., **The Birth of Language: The Case History of a Non-Verbal Child,** Springfield, Il.: Charles C. Thomas, 1966.

[39] Creel, D. J., Bendel, C.M., Wiesner, G.L., Wirtschafter, J.D., Arthur, D.C., and King, R. A., Abnormalities of the Central Visual Pathways in Prader-Willi Syndrome Associated with Hypopigmentation, **The New England Journal of Medicine,** Vol. 314, No. 25: 1606-1609, 1986.

[40] Gary, A.L., and Glover, J., **Eye Colour, Sex and Children's Behaviour,** Chicago: Nelson Hall, 1976.

Worthy that light eye colour and dark eye colour have differing cognitive styles associated with them: they claim that the light coloured eye usually belongs to an individual who is "self-paced", who functions best when stimuli are regular and change little, and when there are rather broad time limits in which to respond; the dark coloured eye usually belongs to an individual who is "reactive", who functions best when stimuli are erratic, changeable, and when a quick response is essential to survival and success. These opposed cognitive styles Worthy saw in the animal world, where two sorts of behavioural set may be seen: the react-approach-flee behaviours of dark-eyed animals, and the wait-freeze-stalk behaviours of light-eyed beasts. In the human sporting sphere, activities such as golfing and snooker fit the operational definition of self-paced activities, while boxing and table-tennis are clearly reactive.

The amount of light entering the eye seems directly related to activation level, and so pigmentation may control activation by this means, probably through adrenaline release. The reactive style dark-eyes would be less able to inhibit responses than the self-paced light-eyes, while the self-paced individual would require elaborate preparation, great attention to detail, and much rehearsal before being happy about doing something. Worthy claimed that light-eyed people are more sensitive to form, while the dark-eyed respond more to colour;[42] Gary and Glover tested this, finding that in a series of tasks, the dark-eyed made more form errors than colour errors, the light-eyed performing conversely. In tasks which measured ability in paper and pencil work, play, and dexterity, dark-eyed individuals scored more highly than light-eyed individuals, although no difference was found in the areas of number work and gross motor skills.[43] The dark-eyed may be of a more addictive personality type, unable to inhibit responses to drugs or alcohol, whereas light-eyed, light-haired, and fair-skinned individuals seem more susceptible to hypoglycaemia[44] Supporting the claim cited above by Kastein, Happy and Collins[45] are cited by Gary and Glover as having theorised that there is a link between autism and light eye and hair colour: the lack of melanin may leave nerve cells in the ascending reticular activating system less protected, sometimes causing a defect in noradrenergic pathways which could bring about autistic symptoms. They found that there was a statistically significant over representation of relatively low pigmented autistic children in their sample, a difference by comparison with dark autistics significant at the .05 level. Self-paced activities, an insistence on elaborate preparation, and an unhappiness with sudden stimuli are, indeed, typical of

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41 Worthy, M., **Eye Colour, Sex and Race: Keys to Human and Animal Behaviour**, U.S.A.: Droke House/Hallux, 1974.

42 p. 88, Gary and Glover.

43 Gary, A.L., and Glover, J., Melanin as a Predictor in the Acquisition of Developmental Skills, **The Journal of Psychology,** 90: 185-190, 1975.

44 p.112, Gary and Glover.

45 Happy, R. and Collins, J.K., Melanin in the ascending reticular activating system and its possible relationship to autism, **Medical Journal of Australia**, 2: 1484-1486, 1972.

autistics. Happy and Collins stated that eye-colour was the best and most reliable predictor of melanin implication in the ARAS.

Gary and Glover conducted a study into the possibility of being able to predict learning disability from eye colour; their experiment had an N of 5552 males and 4012 females identified as having learning disabilities: their conclusions were that dark-eyed students seemed less likely to be learning disabled, regardless of their sex, and that light-eyed individuals were more likely to be learning disabled, especially if they were male.[46] The same study found that the light-eyed are much more likely to suffer diagnosed medical conditions and have various physical anomalies, the ratio being 30 to 1. Those individuals low in pigmentation are therefore 30 times more likely than the highly pigmented to suffer heart, endocrine, and central nervous system disorders, and in addition are more likely to be unusually obese, thin, short, tall, or have premature or delayed secondary sexual characteristics.

Schacter *et al* (1987), who, as was noted earlier, found elevated levels of non-right-handedness in blondes, discussed the Geschwind and Behan hypothesis (1982) that intra-uterine influences which slow rates of neuronal migration and assembly in the left hemisphere may use melanin as a mediating agent-albinos have anomalous visual pathways, increasing the frequencies of strabismus, nystagmus, absence of stereoscopic vision or abnormal refraction, so that melanin may be important for the proper development of the CNS, especially in the area of vision. Blondes, lacking in melanin, may therefore be more susceptible to developmental slowing agents in the uterus such as testosterone. Those who suffer from harelips and cleft palates are more likely to be blond, while rates of neural tube defects are higher in Northern Europe, the home of the blond, than in the Far East; it is from the neural tube that the neural crest arises, and from that the skin and bones of the skull, together with pigmented cells.

Geschwind and Galaburda (1987) note that the Siamese cat, with its hypo pigmented or irregularly pigmented eyes (*heterochromia iridis*-the most notable human example is David Bowie, the musician, whose real hair colour is blond), suffers from strabismus and anomalous visual pathways similar to those suffered by human albinos (Creel, 1986); they mention early research (Mieses-Reif, 1936) which showed that refraction defects were reported more commonly in those with light colouration, and Tisserand's finding (1949) that harelips were found more often in individuals of light pigmentation. Geschwind and Galaburda go on to state their clinical impression that pigmentary anomalies, including early grey or white hair, are more common among individuals with anomalous dominance, notable amongst whom are those, such as dyslexics, who suffer from childhood learning disorders. Early grey or white hair is associated with some autoimmune diseases (pernicious anaemia and autoimmune thyroid disorder) and immune diseases (immune thyroid disease). Early greying is more common among North Europeans

[46] p. 127, Gary and Glover.

than Mediterraneans or Far Eastern peoples, Caucasians greying at around 35 years, with Afro-Caribbeans going grey at around 45 years. While the Japanese would be expected to share Far Eastern late greying patterns, the stress of their extreme work ethic may be the cause of the grey heads often seen in Japan at 30. Perhaps anomalous dominance may also be more common among North Europeans than among those who live in warmer climes. Geschwind and Galaburda state: "...we believe that skin pigmentation and iris pigmentation both reflect immunological, endocrinological, and dominance characteristics."[47] It may be possible that sufferers from vitiligo, patches of lost pigmentation on the limbs and body which derive from the immune system's scattered attack on skin melanocytes, are anomalously dominant, as well. Psoriasis, as suffered by Dennis Potter, John Updike, and August Strindberg, men of letters all, may be of interest, as well (all three had or have red hair and blue eyes-it would be interesting to check psoriasis sufferers' cerebral dominance and hair and eye colour).

Reaction time is a measure which has been used to look for eye colour differences: Landers *et al* (1976) found a significant difference between the performance of dark- and light-eyed individuals on the reaction time component of a choice-response task;[48] if the total response time was separated into reaction time, the interval between stimulus presentation and the initiation of the response, and movement time, the period between the initiation of the response and its termination, the reaction time component was significantly influenced by the colour of the subjects' eyes, light-eyed individuals being slower. Tedford *et al* (1978) similarly found a significant eye colour effect in a simple response time test, with, again, the light-eyed being slower.[49] This group used a more complex choice reaction time task as well, but found only a non-significant trend in the same direction. Hale *et al* used electromyography to fractionate total response time into premotor and motor components, demonstrating that only the premotor component approached significance in times between eye colours, lending support to Landers *et al* (1976). Such results were assumed to indicate the implication of central processing, rather than peripheral mechanisms, in the differences observed in reaction time; patellar reflex time was fractionated by eye colour and no significant difference was found, supporting this assumption. Hale *et al* (1980) found reaction time differences between different eye colour groups, although only between extreme dark and extreme light groups, the magnitude being in the range 10-15ms.[50]

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[47] Geschwind, N., and Galaburda, A., **Cerebral Lateralization: Biological Mechanisms, Associations, and Pathology,** Camb. Mass./London, Eng.: Bradford Books, The MIT Press, 1987.

[48] Landers, D.M., Obermeier, G.E., and Patterson, A.H., <u>Iris pigmentation and reactive motor performance,</u> **Journal of Motor Behaviour,** 8 {3}, 171-179, 1976.

[49] Tedford, W.H., Hill, W.R., and Hensley, L., <u>Human eye colour and reaction time,</u> **Perceptual and Motor Skills,** 47, 503-506, 1978.

[50] Hale, B.D., *et al*, <u>Iris Pigmentation and Fractionated Reaction and Reflex Time,</u> **Biological Psychology,** 10, pp. 57-67, 1980.

Reaction time has long been thought to reflect intelligence, Galton (1883) using a similar measure. Detterman (1987) claims that there is little doubt concerning the relation of reaction time to IQ, although conceding that the relationship is a complex one, intelligence quite apparently being made up of many components; he points out, however, that as the complexity of the task increases, so does the relationship of IQ score with reaction time, increasing complexity bringing more of the basic processes of intelligence to bear.[51] Professor Arthur Jensen, of the University of California, speaking at the annual meeting of the American Association for the Advancement of Science, reported on a reaction time experiment with 147 male subjects at Berkeley, in which there was found a relationship between the neural conductance velocity and a general intelligence factor, "g". The tests, which examined the speed with which a visual stimulus was transmitted along nerves to the visual cortex, showed that the slower the speed of conductance, the lower the IQ scores, while the faster neural conductance was correlated with higher IQ scores.[52]

It has often been said that the suspiciously "easy" negative correlation of fast reaction time and IQ scores must come about through some third, causal factor. Followers of Jensen insist that it is the "quality" of the brain which is the causal factor: highly efficient neural transmission=fast reaction times. If a really elementary mental operation was found which did **not** correlate with IQ, however, the "good organ" theory would be immediately falsified. Inter hemispheric transmission times were thought to be such an elementary mental operation, but, as Necka (1990) notes, results of an experiment using just this measure did not support the "good organ" theory.[53] Perhaps pigmentation could be the third factor.

Markle (1975) found that dark-eyed subjects gave more colour responses on the Rorschach test relative to light-eyed subjects, who tended to give more form responses than the dark-eyed.[54] Gustav Jahoda (1971) looked at illusion susceptibility and space perception, seeking to support the hypothesis that predicted the darker the retinal pigmentation, the greater the susceptibility to the Muller-Lyer illusion when it is drawn in red, rather than blue; another hypothesis was that contours drawn on a map in blue will be less well detected by dark-eyed individuals. He followed the line of reasoning that greater retinal pigmentation reduces contour detectability, so reducing the blue Muller-Lyer illusion and the ability to disentangle blue contour lines on a map: his hypotheses were supported.[55] Coren and Porac (1978) produced

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[51] Detterman, D.K., What does reaction time tell us about Intelligence? in Vernon, P.A., {ed.} **Speed of Information Processing and Intelligence**, New Jersey: Ablex Publishing Company, 1987.
[52] Williams, N., Brain speed link "to intelligence", **The Guardian,** 19/2/91.

[53] Necka, E., Reaction Time and Intelligence, **European Journal for High Ability**, Vol. 1, No. 1/2, 1990.
[54] Markle, A., Colour and Form Perception on the Rorschach as a Function of Eye Colour, **Perceptual and Motor Skills,** 41: 831-834, 1975.
[55] Jahoda, G., Retinal Pigmentation, Illusion Susceptibility and Space Perception, **International Journal of Psychology**, Vol. 6, No. 3: 199-208, 1971.

results which supported Jahoda, although they seem not to have known of his work at Strathclyde University: in a large sample (755) illusion magnitude did, indeed, vary as a function of iris pigmentation.[56] Pollack and Silvar (1967),[57] and Ebert and Pollack (1972),[58] are others who have found similarly.

John Beer and his various associates have been inspired by the work of Worthy and Gary and Glover to look at all sorts of motor skills and eye colour: physical education activities in school children (1987),[59] basketball target shooting (1987),[60] typing speed (1987),[61] frisbee tossing (1988),[62] rope jumping by school children (1988),[63] horseshoe pitching (1989),[64] ball throwing by school children (1989),[65] accuracy in archery (1989),[66] and the Bruninks-Oseretsky Test of Motor Proficiency (1989).[67] Beer *et al* had less than consistent success: only in target basketball throwing and frisbee tossing did they get a significant result, finding that the dark-eyed hit their targets more often than the light eyed; unfortunately for the Worthy theory, these were both self-paced activities which should have been performed better by light-eyed individuals.

Rosenberg and Kagan (1987, 1989) found that there was a statistically significant relation in Caucasian children between behavioural inhibition to the unfamiliar and blue irises, and uninhibited behaviour and brown irises. Blue eyed children from 21 months of age showed physiological signs of anxiety and stress more often than brown eyed children of the same ages, including irritability, colic, chronic constipation, and allergies. They were afraid of the dark, animals and loud sounds

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[56] Coren, S., and Porac, C., Iris Pigmentation and Visual-Geometric Illusions, **Perception,** Vol. 7: 473-477, 1978.

[57] Pollack, R.H., and Silvar, S.D., Magnitude of the Muller-Lyer Illusion in children as a function of pigmentation of the Fundus oculi, **Psychonometric Science**, Vol. 8 {2}: 83-84, 1967.

[58] Ebert, P.C., and Pollack, R.H., Magnitude of the Muller-Lyer Illusion as a function of lightness contrast, viewing time, and Fundus pigmentation, **Psychonometric Science**, Vol. 26 {6}: 347-348, 1972.

[59] Beer, J, and Fleming, P., Eye Colour and Motor Performance in Physical Education Activities in Elementary School Children, **Perceptual and Motor Skills**, 64: 963-967, 1987.

[60] Beer, J., and Fleming, P., Effects of Eye Colour on Set Shots in Basketball Pig Contests, **Perceptual and Motor Skills**, 65: 885-886, 1987.

[61] Beer, J., and Neeley, M., Effects of Eye Colour on Typing Speed, **Perceptual and Motor Skills**, 65: 893-894, 1987.

[62] Beer, J., and Fleming, P., Effects of Eye Colour on Frisbee Tossing, **Perceptual and Motor Skills**, 66: 675-676, 1988.

[63] Beer, J., and Fleming, P., Effects of Sex and Eye Colour on Jumping Rope by Elementary School Children, **Perceptual and Motor Skills**, 66: 837-838, 1988.

[64] Beer,J., and Beer, J., Relationship of Eye Colour to Winning Horseshoe Pitching Contests, **Perceptual and Motor Skills**, 68: 136-138, 1989.

[65] Beer, J., and Fleming, P., Effects of Eye Colour on the Accuracy of Ball Throwing of Elementary School Children, **Perceptual and Motor Skills**, 68: 163-166, 1989.

[66] Beer, J., Fleming, P., and Knorr, W., Effects of Eye Colour and Sex on Accuracy in Archery, **Perceptual and Motor Skills**, 68: 389-390, 1989.

[67] Beer, J., and Fleming, P., Relations of Eye Colour to Scores on Bruininks-Oseretsky Test of Motor Proficiency-Short Form, **Perceptual and Motor Skills**, 68: 859-862, 1989.

significantly more than their brown eyed peers.[68] [69] Rubin and Both (1989) found similarly.[70] Kagan and his associates over the years have identified the two childhood personality types they call "inhibited" and "uninhibited": major operational signs of inhibition are those mentioned above, together with trying to move away from unusual or suddenly appearing objects or events, and a reluctance to interact with them-they stop playing and fall silent in that circumstance; when taken to an unfamiliar setting they tend to cling to their parents more than children identified as belonging to the uninhibited group. Operational signs of lack of inhibition are the exact converse of those just described.

Physiological data reveal that the inhibited children have a higher and more stable heart rate, larger pupillary dilation, and higher cortisol levels under conditions of cognitive stress, suggesting greater responsivity in the limbic system and hypothalamus.[71] Further emphasising the associations found between light eye colour and physical and cognitive disadvantage noted here earlier, Rosenberg and Kagan cite studies linking blue-eyed individuals to phenylketonuria, and neural crest syndrome, this last a disorder characterised by congenital abnormality in pain perception and autonomic system dysfunction. They go on to cite research on differing cognitive styles between the light- and dark-eyed: the light-eyed have been identified as being more likely to be field dependent, introverted, and "shy".[72] From their findings, Rubin and Both would predict that brown-eyed children would be significantly over represented in groups identified as conduct-disordered or aggressive.[73]

David Lester (1974) devised a theory of personality based on physiological traits which, while not cited by any of the preceding authors, seems to support the hypothesis that the autonomic nervous system is important in elucidating these many and various associations with eye colour. The sympathetic and the parasympathetic systems are invoked as the dominant physiological structures in two types of individual, appropriately termed the "**S**" and the "**P**" type. The sympathetic system, with its neurochemicals acetylcholine and noradrenalin, would dictate the "**S**" type's personality style, while the parasympathetic system, which is wholly cholinergic, dictates the "**P**" personality style. Lester cites Kent (1956),[74] who reported that blue-eyed people have lower pulse pressure, higher pulse rate, higher respiratory rate, and higher oral temperatures than brown-eyed people. Lester uses

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[68] Rosenberg, A., and Kagan, J., Iris Pigmentation and Behavioural Inhibition, **Developmental Psychobiology**, 20 (4): 377-392, 1987.

[69] Rosenberg, A., and Kagan, J., Physical and Physiological Correlates of Behavioural Inhibition, **Developmental Psychobiology**, 22 (8): 753-770, 1989.

[70] Rubin, K.H., and Both, L., Iris Pigmentation and Sociability in Childhood: A Re-Examination, **Developmental Psychobiology**, 22 (7): 717-725, 1989.

[71] Rosenberg and Kagan, 1987, p. 378.

[72] **Ibid**, p. 379.

[73] Rubin and Both, 1989, p.723.

[74] Kent, I, Human iris pigment, **Canadian Psychiatric Association Journal**, 1:99-104, 1956.

this and other evidence to conclude that blue-eyed people are "**S**" types while brown-eyed people are "**P**" types.[75] If this is the case, it is in line with Rosenberg and Kagan's supposition that light-eyed individuals have a lower threshold of physiological arousal, a consequent continual risk of over stimulation of the sympathetic system, producing a need to avoid such over stimulation which results in inhibited behaviour. Such people may well possess the detested "clammy" handshake, be mesomorphic, field dependent, and have a tendency to manic-depression, or paranoia. The brown- or dark-eyed, conversely, have a high threshold of stimulation, need strong stimuli to meaningfully experience anything, and therefore exhibit uninhibited behaviour in order to seek out these strong stimuli. Interestingly, Lester links the latter type to endomorphy, drug abuse, schizophrenia, field independence, and maleness.

Rosenberg and Kagan (1989) propose, among other explanatory biological mechanisms, that if there is a set of genes in the pregnant mother that produce high levels of noradrenalin or corticotrophin releasing hormone (a substance which stimulates cortisol production) in the first weeks of pregnancy placental cortisol may inhibit transcription of the proopiomelanocortin substance (POMC), thereby limiting synthesis of its derivatives, alpha-melanocyte stimulating hormone (A-msh) and beta-endorphin (B-end: an endogenous opioid); B-end mitigates pain perception, reduces arterial blood pressure, and decreases vascular sympathetic tone, while A-msh is a pituitary hormone known to stimulate melanin pigment synthesis and is present throughout the brain structures that are critical to limbic arousal. These two peptides are synthesised in equimolar amounts, derived from their common precursor, POMC. It is possible, therefore, that individuals who have low levels of POMC also have low levels of A-msh and consequently light eyes, as well as low levels of B-end and so low thresholds of physiological arousal. Cortisol facilitates the enzymatic action of dopamine-beta-hydroxylase, which catalyses the last step of the formation of noradrenalin, enhancing the development of adrenergic rather than cholinergic neurones in the autonomic nervous system, so predisposing toward a sympathetic ANS dominant individual. Both noradrenalin and cortisol can cause melanocytes to contract, inhibiting melanin dispersal. As a result, high levels of embryonic or placental cortisol may inhibit melanin distribution as well as making the amygdala more excitable. A woman who produced high levels of cortisol during early pregnancy may thus be expected to have a light-eyed child who would be more likely to respond to stress with sympathetic discharge.[76] There is a strong link here with Geschwind and Galaburda's testosterone theory, the same common embryological derivation they observe for many of their associations of immune system and brain structures, the neural crest, is observed by Rosenberg and Kagan for pigment cells and structures

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[75] Lester, D., **A Physiological Basis for Personality Traits: A New Theory of Personality**, Springfield, U.S.A.: Charles Thomas, 1974.

[76] Rosenberg and Kagan, pp.767-768, 1989.

influential on the expression of inhibition: melanocytes, sympathetic ganglia, pituitary, and adrenal medulla all develop from the neural crest of the embryo.[77]

Other areas of the brain may be implicated, however: melanin has been found to aid speed of neural switching in the central nervous system,[78] and is concentrated in certain areas of the brain such as the substantia nigra, and in a column which extends the length of the brain stem which has within it the dorsal motor nucleus, locus coeruleus, the lateral tegmental area, and the globus pallidus. The locus coeruleus and the lateral tegmental area are the main sources of brain noradrenalin, and both sites send extensive projections to the limbic system as a whole. The anatomical distribution of nerve cells containing neuromelanin (neuromelanin is not produced by melanocytes: it is the product of the auto-oxidation of catecholamines in the nerve cells; iris melanin is produced within the melanocytes, requiring the enzyme tyrosinase to convert DOPA to DOPA-quinone and finally to the production of melanin) parallels the distribution of catecholaminergic cells, which suggests a neuromelanin-dopamine-noradrenalin link, say Rosenberg and Kagan (1987). Neuromelanin binds the other two *in vitro*; it follows that higher levels of neuromelanin should be associated with lower levels of noradrenalin in the brain; as noradrenalin increases the excitability of the limbic and autonomic systems, the end result should be that lower concentrations of neuromelanin could be associated with greater excitability in some limbic sites. Noradrenalin also inhibits the dispersal of melanin within melanocytes, higher levels of noradrenalin possibly being associated with light eyes, and, conversely, lower levels being associated with dark eyes.[79]

It seems clear that there exists a complex set of interrelationships between neuromelanin, iris pigmentation, dopamine, noradrenalin, the activity levels of the limbic system, CNS and the ANS. Positive correlation between levels of iris melanin and neuromelanin in the stria vascularis of the cochlea, an area containing melanocytes, may derive from their metabolic precursors affecting them through the action of related derivatives. Although obscure at the moment, it seems very likely that intimate links do exist between these pigmented structures. Schachter *et al* (1987) point out that the evidence that melanin may modulate neural development is incomplete, as is obvious, although it does seem to be necessary for the proper development of the central nervous system pathways involving vision; Geschwind and Galaburda (1987) indicate that if there is a reduction of melanin in the brain then neural development may be slowed, incomplete, or distorted.

Worthy's self-paced individuals and Rosenberg and Kagan's inhibited individuals seem very similar types. If noradrenalin is the main neurotransmitter in the

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[77] **Ibid**, 1989.

[78] McGinnis, J., Corry, P., and Proctor, P., Amorphous Semiconductor Switching in Melanins, **Science**, 183: 853-855, 1974.

[79] Rosenberg and Kagan, pp. 387-388, 1987.

Reticular Activating System, the nerve net which maintains consciousness and attention, then high levels of noradrenalin would produce someone almost painfully aware of everything going on, noises, unexpected strangers, small details of everyday life, and, as a consequence, they would surely try to maintain as much order and routine as possible, objecting violently to any alterations to that routine which may bring unpleasant over stimulus; this is quite close to a classic description of the behaviour of the autistic child, who, as Happy and Collins (1972) found, are more likely to be light eyed. Obviously, this is the most extreme end of a spectrum of disadvantage which in the normal population may show itself in more subtle fashion.

It appears that light eye colour is associated with learning disability, dyslexia and autism; if that is so, those individuals who do not necessarily suffer the most extreme effects of hypo pigmentation may, nevertheless, demonstrate reduced left hemisphere cognitive functions, relative to the dark-eyed and dark-haired. Reduced left hemisphere abilities may well incline the individual to follow a discipline more suited to his or her strengths in the visual-spatial area. If the dark-eyed are faster to react by virtue of being free from neurotic inhibition, then a reaction time measure would show them to be faster than the, possibly, more neurotic and inhibited light-eyed, as studies have already indicated. It follows that the artistic disciplines may contain more relatively right hemisphere dominant light-eyed individuals, who may function overall at a lower level than the dark-eyed.

Postgrads and Regions Of Rejection

If the areas of the left hemisphere are slowed in their development this may not mean that they are permanently reduced in size and capability, but rather that they simply take much longer to develop, allowing competing areas to surpass them in the short term. Indeed, a longer period of growth may enable the left hemisphere as a whole to attain a greater final size than the right. Nevertheless, while this is taking place, the left-handers may excel in early education. As many of the career-determining examinations occur early in life, left-handers may be found in increased numbers in higher education, including those disciplines which demand strong verbal ability.

Nonetheless, this extended growth period renders the left hemisphere susceptible to damage or deleterious affects for a longer time than the right side. In addition, when full development is not achieved through excessive growth retardation, premature birth, or early puberty, learning deficiencies may result, and perhaps an overall inferior level of functioning. The anomalous development of certain areas of both hemispheres may therefore be found at both the higher *and* lower ends of the normal distribution curve of accomplishment. These could be called the "regions of rejection" for more reasons than the usual statistical one: psychologists, with few exceptions, have turned their faces away from such extremes and paradoxes, preferring instead to study the normal. If all this is correct, the apparently contradictory claims that both high and *low* mathematical ability is to be found in elevated frequencies among dyslexics, that both *high* and *low* spatial ability is more common among left-handers, could be reconciled as equally true. If there is a U-shaped non-linear rather than a simple linear relationship between, for instance, spatial performance and the male-related effect in development, there may be an optimal hormonal level required; excessive effects would occur mostly in males, who would be found in greater numbers in areas of both high and low ability. Porac and Coren's analysis of 1912 Canadian college entrants offers some support for this conclusion, when they looked at students ranked in the top and bottom 25% for reading speed, and found that, when compared for handedness, the best contained 8.1% and the worst 12.2% left-handers.[80] It is a less dramatic scenario for females, because few would be in the dosage range that would lead to a lessening of function. It follows that left-handed females would be more often found in the high spatial talent group than in the low scoring group. They follow (reverting once more to statistical terminology) a "one-tailed" direction, while the males are clearly "two-tailed"! If the above reasoning is correct, then such females might well be found in *any* high talent group.

<u>The Stable Female And The Throw-Away Male</u>

Geschwind and Galaburda point out that such a mechanism is desirable in evolutionary terms:

> The possible existence of bimodal effects...is not surprising from the perspective of biological fitness. If two populations share the same *mean* level of performance of some function the two groups are not necessarily equally competitive. Assume that one population contains a higher percentage than the other of individuals with both very high and very low talents for this function. The population with higher numbers in the extreme range may compete more effectively since success often depends primarily on the performance of those individuals in the highest ranges...A process affecting brain growth that produced high talents in a large number at the expense of an unusual number of incompetents would be favoured in the course of evolution. A mechanism of this type may not readily be detected, because of the small numbers of individuals in the tails of the distributions.[81]

Males, with their higher numbers in the highest reaches of Mathematics, Art, Architecture, Engineering and other areas of skill requiring high spatial ability, pay for this by being more likely than females to suffer all the pathologies previously mentioned, in addition to a reduced life expectancy. For males, there are always as many snakes as there are ladders. Evolutionarily, it would make more sense for females to have greater stability, and be less extreme in the biological credit and debit areas, to preserve the stability of the species and ensure children are produced as often and as healthily as possible. Males are obviously more "throw-away": biological risks may be taken in their case, and if a gamble comes off spectacularly

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[80] cited in Annett, p.87.
[81] p.523, Geschwind and Galaburda, June,1985.

well, the species as a whole benefits, if not, little is lost. The fact that out of 140 males conceived only slightly fewer than 100 survive into infancy seems to indicate that the evolutionary dice are loaded against the male. Poorer health all round may be expected in males, with more variance in their cognitive test scores.

Depression, Schizophrenia, And The Division Of Mental Labour

The evidence detailed in the previous section may account for the greater incidence of the "genius" in the male, an extreme type, very finely divided from what are considered, in the terms of our contemporary literate and highly communicative culture, the disadvantaged types of the dyslexic and the autistic, but possibly deriving from the same causes. Dryden once said:

Great wits are sure to madness near alli'd,
And thin partitions do their bounds divide,
(**Alexander's Feast,** 1.4, lines 163-164)

Often, great talent has been associated with mental illness. Depression has been identified by many researchers as having its biochemical origins in the right hemisphere, and some have linked depression with the catecholamines and serotonin.[82] Mann *et al* (1992) report that serotoninergic indexes correlate with suicidal behaviour and affective disorders; they found a positive correlation between cerebrospinal fluid 5-hydroxyindoleacetic acid (CSF 5-HIAA) and the maximal prolactin response to fenfluramine (but not with platelet serotonin$_2$ receptor indexes); fenfluramine-stimulated maximal prolactin response correlated with platelet serotonin$_2$ receptor number, particularly in older individuals, the overall concentration of CSF 5-HIAA correlating with serious suicidal behaviour.[83]

Intelligence, too, seems associated with levels of 5HT: Cook, Leventhal, and Freedman (1988) found that blood serotonin was elevated in 30% of autistic children and 50% of severely mentally retarded children, while in normals there was a trend toward a negative correlation between whole blood 5HT and Vocabulary scores on the WAIS-R, with female subjects having significantly greater whole blood 5HT than the males. They note that in the past whole blood serotonin levels have been shown to be increased in autistic children, and that the weight of the experimental evidence supports their findings of a negative relationship between measures of IQ and whole blood serotonin levels.[84] If IQ tests are most typified by the left

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[82] Gastpar, M., L-HTP and the serotonin hypothesis, their meaning for treatment of depression, in J. Obiols, C. Ballus, E. Gonzalez Monclus, and J. Pujol (eds.), **Biological Psychiatry Today,** Amsterdam: Elsevier/North Holland Biomedical Press, 1979.

[83] Mann, J. J., McBride, P.A., Brown, R.P., *et al*, Relationship Between Central and Peripheral Serotonin Indexes in Depressed and Suicidal Psychiatric Inpatients, **Archives of General Psychiatry,** Vol. 49, June, 1992.

[84] Cook, E.H., Leventhal, B.L., and Freedman, D.X., Serotonin and Measured Intelligence, **Journal of Autism and Developmental Disorders**, Vol. 18, No. 4, 1988.

hemisphere dominated verbal sub-tests, and serotonin levels may be an index of right hemisphere activity relative to that of the left hemisphere, then one may predict that autistics, the mentally retarded, and perhaps artists, to differing extents, may show a similar negative relationship. The right hemisphere is where the appreciation of colour is supposedly located, together with the holistic grasp of overall form and general integration of perceptual information, essential for conveying and interpreting emotion. Visual-spatial performance is poor in depressed children, it appears, while the degree of depressive mood has been closely associated by some researchers with EEG activity in the right frontal region. Manic phases seem to improve holistic perceptual skills, however. In his review of such work, Tucker[85] states that the manic is hyper prosodic, hyper sexual, and socially extroverted, with holistic and expansive ideation, remote associations primed and accessible to current working memory.

The right parietal region seems to be involved not only in the comprehension of emotional communication, but also in regulating arousal and orienting attention. There appear to be connections from that region to regions of the dorsal limbic system, where adaptive significance is assigned to perceived objects. The right hemisphere may well have closer links than has the left hemisphere with the brain stem, and therefore with basal emotions.[86] Animal studies show that after frontal right hemisphere lesions there is a decreased level of both the noradrenaline and dopamine neurotransmitters, but also increased emotional activity. Roy, Karoum, and Pollack (1992) have found that depressed patients who had attempted suicide had significantly smaller urinary outputs of homovanillic acid and total body output of dopamine than did patients with depression who had not attempted suicide. Those patients who, within a five year follow-up period, had re-attempted suicide had significantly smaller sum dopamine (body output) than did patients who did not re-attempt suicide, patients who had never attempted suicide, and normal controls; diminished dopaminergic neurotransmission may play a part in suicidal behaviour in depression.[87] Extreme emotions produce the most extreme behaviour.

Noradrenaline neural pathways have a regulatory control bias for habituation, say Tucker and Williamson, perhaps causing the brain to orient to novelty, giving the right hemisphere, where those pathways predominantly exist, an expansive, attentional mode, the primitive substrate to the right hemisphere holistic cognitive, and perceptual skills. Dopaminergic pathways in the right hemisphere are important for motor readiness and lead to repetitive and stereotyped actions. In

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[85] Tucker, D.M., and Frederick, S.L., in Chapter Two, Emotion and Brain Lateralization, of Wagner, H., and Manstead, T., (eds) **Handbook of Psychophysiology: Emotion and Social Behaviour**, N.Y., John Wiley, 1989.

[86] p.25, Ibid.

[87] Roy, A., Karoum, F., and Pollack, S., Marked Reduction in Indexes of Dopamine Metabolism Among Patients With Depression Who Attempt Suicide, **Archives of General Psychiatry**, Vol. 49, June, 1992,

schizophrenia this apparent redundancy bias may be functionally exaggerated.[88] It is possible that damage to the right hemisphere might lift callosal inhibition from the left hemisphere, releasing its naturally active and curious nature. Hyperactivity, too, is sometimes shown after right hemisphere lesions.[89] The left hemisphere may, through its sequential and analytic ideation, act as an inhibitor of personality.[90] Craft, Gourovitch, Dowton *et al* (1992) report that in children with early treated phenylketonuria, which results in general catecholamine depletion, there is an association with left hemisphere deficit in visual attention, primarily in males. Such a sex difference finding, as with the above 5-HT evidence, can be explained by reference to Geschwind and Galaburda's testosterone theory, which would predict that the male left hemisphere, having been retarded in its development by the high level of testosterone in the foetal environment, would have had longer to be adversely affected by any such disruptive depletion of catecholamines. Other disorders such as schizophrenia and Tourette's syndrome may produce a similar sex difference in left hemisphere function.[91]

Tucker speculates that it may be in the right hemisphere that the subjective experience of felt significance is added to perception. From such organic interconnections may rise the most powerful of numinous experiences in the perception (if not the production) of art and the experience of religion. Tucker goes on to suggest that to rely on right hemisphere processing is to represent reality in analogue form, to have mental representations which closely mirror environmental events, together with internal bodily processes. It is phenomenologically rich as a mode of perception, **concrete**, with the perceptual process easily touching the dynamics of emotion. He sees a strongly right hemisphere dependent person as having such a wholly extroverted orientation that syncretic fusion of experience merges self and context, a conception which may serve to illuminate both the artistic and the autistic condition, conditions which may depend on a wholly different and opposite orientation.

Recent research with children who have right hemisphere injuries has found that they are developmentally impaired in copying, while their free drawings lack configurational coherence; the drawing elements were without spatial organisation, as with the depressed children mentioned earlier.[92] Left hemisphere damaged children produced developmentally normal art works.[93] Lovis Corinth, a rather weak and watery German Impressionist at the turn of this century, became a strong

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[88] p.33, Ibid.
[89] p.30, Ibid.
[90] Ibid, p. 18.
[91] Craft, S., Gourovitch, M.L., Dowton, S.B., Swanson, J.M., and Bonforte, S., Lateralised deficits in Visual Attention in Males with Developmental Dopamine Depletion, **Neuropsychologia**, Vol. 30, No. 4, pp. 341-351, 1992.
[92] As in Manet's work.
[93] Stiles-Davis, J., Janowski, J., Engel, M., and Nass, R., Drawing Ability in Four Young Children with Congenital Unilateral Brain Lesions, **Neuropsychologia**, Vol. 26, No. 3, pp.359-371, 1988.

and emotional Expressionist almost overnight when, in December, 1911, he suffered a right hemisphere stroke. For a while he had a weakened left side and deep depression (Tucker quotes researchers who have found that the further from the frontal areas such injuries occur, the greater the depression which follows[94]). Howard Gardner uses a quotation from a contemporary art critic to illustrate the changes which took place in Corinth's work:

> The contours disappear, the bodies are often as if ript asunder, deformed, disappeared into textures...all detailed execution come to nothing...Characterisation is now exaggerated, indeed often to caricature.

Gardner goes on to point out how Corinth's loss of contour, misplacement of details, neglect and obscuring of texture (mostly of the left side of the working surface), increased subjectivity, idiosyncrasy, and obscurity, all indicate right hemisphere damage.[95] Such injury, or perhaps neurochemical dysfunction, may release in the right hemisphere subcortical emotional responses, as seen in unipolar depression; they may be freed of the inhibitory controls of the evolutionarily more recent associative cortical areas. In the light of the evidence quoted above, it may be that it is the **balance** of neurochemicals which in turn affects the **balance** of hemispheric activity, and the consequent cognitive style, artistic style, and general emotional level, experience of the world and behaviour.

Schizophrenia, as has been theorised above, may originate in a malfunctioning of the biochemical production of the left hemisphere, which is the probable location of the formal structuring abilities, together with the analytical grasp of fine detail and line. The suggestion that the left hemisphere is both highly activated and yet dysfunctional in schizophrenia is often touted in current research.[96] Gur, Skolnick, Gur *et al* (1983) found schizophrenics had a normal regional cerebral blood flow at rest, but an abnormally high left hemisphere blood flow during a spatial task, as though, perhaps (the rCBF pattern of females attempting such tasks was similar) they had tried very hard to solve a spatial problem by a verbal strategy, or by inappropriate left hemisphere analysis of the task into discrete parts.[97] David and Cutting (1990) used a happy-sad chimeric face test to investigate the role of the right hemisphere in positive and negative affect, both normal and abnormal, as well as in schizophrenics. Patients with focal brain resections have shown that left hemisphere lesions do not alter the bias, whereas right posterior lesions do. This test in normals evokes a left-sided perceptual bias; in depressives the bias was reduced, while it was non-existent in schizophrenics. Manics showed an **increased** bias, explained by the possibility of right hemisphere *hyper* function, while moderate to severe *hypo* function of that hemisphere may account for the results of the

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[94] p.27, Ibid

[95] from p. 291, Gardner, H., **The Shattered Mind**, N.Y., Vintage Books, 1974.

[96] p.13, Tucker and Freeman.

[97] Gur, R.E., Skolnick, B.E., Gur, R.C., *et al*, Brain function in psychiatric disorder: 1: Regional cerebral blood flow in medicated schizophrenics, **Archives of General Psychiatry**, 40, pp. 1250-1254, 1983.

depressives and schizophrenics. Interestingly, normal left-handers show no consistent bias, showing perhaps greater equality of hemispheric functioning.[98]

It is therefore possible that there is a raised incidence of both handicapped and exceptionally gifted individuals in the talented male group, together with a greater tendency toward either bi-polar depression or schizophrenia in both male and female talented individuals. The latter would tend to have little interest in the overall composition, while the depressive variety of the former would tend to reduce detail, but it may be predicted that there would be greater numbers of individuals, both morbid and pre-morbid, with both pathologies in any artistically talented population.

The **graphic tendency** in an artist may show a left hemisphere interest in the cool analysis of detail, evidence of an intellectualised and detail-oriented cognitive style, while a **painterly tendency** may show the emotional right hemisphere interest in overall form, colour and emotion. A preference for black-and-white over colour pictures, an admission of some uncertainty over the boundaries between reality and fantasy or thought, may be associated with maleness and perhaps poor cognitive test scoring due to increased likelihood of pathological thought patterns. Artists may have greater problems of this sort.

"All the World's a Stage..."

In an individual in whom emotion is only loosely controlled, fear very easily becomes uncontrollable panic.[99] Panic, an endless fear of the apparently meaningless and disordered world of experience,[100] is theorised to be the primary characteristic of autistic individuals, only soothed by a strictly ordered, even regimented life, as found, for example, in the Higashi School, Lexington, Boston, Massachusetts, which follows the methods of Dr Kiyo Kitahara, and is supported by Jerome Kagan of Harvard University. What may be termed **"Loss of Reality"** is the sensation that although one may perceive the million and one details of everyday life with frightening clarity, it has all ceased to inhere with meaning and therefore has ceased to cohere.

The Diagnostic and Statistical Manual of Mental Disorders (Third Edition-Revised, 1987) [**DSM III-R**] identifies such a loss of the sense of the reality of things and other people as 'Derealisation', a sub-characteristic of 'Depersonalisation Disorder'; the latter is described (p.275) as:

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98 David, A.S., Cutting, J.C., Affect, Affective Disorder and Schizophrenia: A Neuropsychological Investigation of Right Hemispheric Function, **British Journal of Psychiatry**, 156, pp. 491-495, 1990.

99 pp.37-39, Tucker and Frederick

100 This is often cited as a primary characteristic of the German Expressionists, both in their work and as individuals.

...an alteration in the perception or experience of self in which the usual sense of one's own reality is temporarily lost or changed. This is manifested by a feeling of detachment from and being an outside observer of one's mental processes or body, or of feeling like an automaton or as if in a dream.

Derealisation is frequently associated, where there is

...a strange alteration in the perception of one's surroundings so that a sense of the reality of the external world is lost. Alterations in the size or shape of objects in the external world are commonly perceived. People may seem dead or mechanical.[101]

In young adults some 70% may suffer from episodes of depersonalisation at times of stress or anxiety. Persistent or frequent episodes may be termed Depersonalisation Disorder and can cause severe distress, social and occupational impairment. **DSM-III-R** goes on to point out that depersonalisation may be a symptom in various other disorders, such as schizophrenia, mood disorders, organic mental disorders, anxiety disorders, personality disorders and epilepsy, but by itself cannot be used to diagnose any of them. When derealisation is unaccompanied by depersonalisation there is an indication of dissociation between the normally integrated functions of memory and consciousness, but which is not classified as a specific Dissociative Disorder, one of the Hysterical Neuroses, such as Fugue or Multiple Personality Disorder.[102] Ray, June, Turaj, and Lundy (1992) have used the Questionnaire of Experiences of Dissociation and the Dissociation Experiences Scale with 264 young adults, factor analysing their responses: among factors which emerged from the scales, which correlated well with each other ($r=0.820$, $p< 0.001$), were 'Different Selves', 'Depersonalisation', 'Process Amnesia', 'Fantasy/Daydream', 'Trance', and 'Imaginary Companions'. It seemed that there was much more experience of dissociation in this normal population than had been suspected.[103]

Louis Sass (1990) has detailed the phenomenology of the *Stimmung*, an experience common in the early stages of schizophrenia, when the imminent or potential schizophrenic experiences a profound derealisation; they stare, fascinated, at the changed world before them-it is the "truth-taking stare".[104] Sass distinguishes four stages of the *Stimmung:*

1) *Trema* ("stage-fright"): he quotes 'Renee', a schizophrenic patient, as describing the world in this stage as "...vast, empty, and infinitely precise, yet somehow devoid of the normal sense of emotional vibrancy, human purpose, or authenticity...Objects are stage trappings, placed here and there, geometric cubes without meaning."[105]

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101 p.276, **DSM-III-R**, American Psychiatric Association, Washington, USA, 1987.

102 p.277, **Ibid.**

103 Ray, W.J., June, K., Turaj, K., and Lundy, R., Dissociative Experiences in a College Age Population: A Factor Analytic Study of Two Dissociation Scales, **Personality and Individual Differences**, Vol. 13, No. 4, pp. 417-424, 1992.

104 Sass, L.A., Surrealism and Schizophrenia: reflections on Modernism, Regression, and the Schizophrenic Break, **New Ideas in Psychology**, Vol. 8, No. 3, pp.275-297, 1990.

105 p.276, **Ibid.**

2) *Brutal immanence* : the existence of everything becomes overwhelming: 'Renee' describes this:

When, for example, I looked at a chair or a jug, I thought not of their use or function, a jug not as something to hold water and milk, a chair not as something to sit in-but as having lost their names, their functions and meanings; they became 'things' and began to take on life, to exist.[106]

3) *Fragmentation* : previously unified or coherent objects seem to disintegrate into parts; again, 'Renee' describes her fear as:

...the individual features of [someone's] face, separated from each other: the teeth, then the nose, then the cheeks, then one eye and the other.[107]

4) *Apophany* ('to make manifest'): a feeling that objects and events are imbued with a tantalising but always out-of-reach and ineffable quality of significance, numinous or suspicious.

When the schizophrenic tries to make the derealisation 'go away', at least temporarily, Sass says that they throw themselves into some form of everyday action, a pragmatic routine, where objects are handled, there is human interaction, and the tangibility of things is reinforced. Inactivity, the passive observation of events, seems to encourage everything to become 'weird'. Sass describes the derealised world of the *Stimmung* as so alienated that the patient has lost any sense of situatedness in space and time, as being possessed by a hypertrophied consciousness which, by concentrating too sharply on the meaningful human world, causes its decomposition and loss of coherence. All parts of the visual field have an equal importance, time becomes a single, unchanging, present moment, and the self is distributed everywhere and nowhere, says Sass.[108] It is reported by him that 'Renee' prefers to refer to herself in the third person, as do autistics, perhaps indicating how little she, and perhaps they, have a sense of self, a perspective, with no grounding in any particular place, time, or body.

It is an interesting speculation that the treatment of other children and adults as "mechanical aids" by autistics[109] could indicate that what is an occasional disturbing episode of derealisation in many adolescents, in those undergoing a panic attack, and in the schizophreniform *Stimmung*, may be the *permanent* perception of at least some autistic children-a constant state of anxiety would be expected in them.

106 **Ibid.**
107 **Ibid.**
108 pp. 292-293, **Ibid.**
109 p.38, **DSM III-R.**

As they grow older they may adapt enough to reduce their anxiety levels but find it difficult to view others as more than mere objects.[110]

Some lesions of the left posterior cerebral cortex result in a patient's inability to make sense of the whole, while being perfectly able to recognise the details from which it is made up. Lesions of the right hemisphere sometimes result in a similar disorder (recall Corinth's fragmented artwork), this time usually confined to face recognition (*prosopagnosia*); the features are seen but not recognised: a picture of a dog's face could be that of a hairy man.... [111] It may be that lesion studies could cast some light on the sort of disorders described above, including derealisation, or **'Loss of Reality'.**

Artists are encouraged to "stare" at the world and people in order to notice all the details and forms usually cloaked by the fog of cultural symbolism; history, use, associations and name must be stripped away from a chair, as in the case of Renee's vision, before it may be depicted fully and clearly by the artist. It may be given a title later, as in Van Gogh's "*Chair* ", but in the production of the painting the painter is not concerned with names; the object of the painting is temporarily as much a meaningless thing as the world of the autistic child appears to be all the time. Interestingly, one of the processes which have been seen to be involved in dissociation together with depersonalisation, amnesia, trance states, and the existence of sub personalities, is that of absorption, absorption in watching a movie, reading a book, or driving a car for extended periods, the ability to be wholly lost in the task at hand. If there is anything which characterises the true artist it is the ability to be wholly lost in the production of the art work.

The Withered Buds of May

As indicated earlier, Geschwind and Galaburda speculate that individuals born in different months of the year may have been subject to differing testosterone levels in their foetal environments: the pineal gland appears to control sex hormone levels throughout the year, reducing them during the dark winter months; this is the reason why many animals bear young during the spring. Humans seem to be less influenced; however, Badian[112] has found that non-right handed *males* are more likely to be born in September, October, November, December, January, and February, thus having been conceived and carried during months when high foetal sex hormone levels would be expected. No such pattern is discernible with females. Evidence which does not support such a position has been found by Dellatolas, Curt, and Lellouch (1991): they report no relationship between handedness and birth

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[110] Discussed in Frith, U., **Autism: Explaining the Enigma,** UK: Blackwell, 1989, especially Chapter 10.

[111] Hecaen, H., and Albert, M.L., **Human Neuropsychology**, New York: Wiley, 1978.

[112] Badian, N., Birth Order, Maternal Age, Season of Birth, and Handedness, **Cortex,** 19: 451-463, 1983.

month.[113] Births of children with neural tube defects are most common in the first three months of the year, say Geschwind and Galaburda. If some left-handers are the result of brain pathology such neural tube defects may contribute to their number. Manoach, Maher, and Manschreck (1988) found that in a sample of 58 schizophrenics left-handedness was both raised and associated with the presence and severity of thought disorder, putting forward the hypothesis that a sizeable proportion of left-handed schizophrenics are left-handed because of a disruption in the pattern of hemispheric dominance that impairs language function as well.[114] In a brief review of Cerebral Laterality and schizophrenia, Castle and Murray (1991) note that studies have found left temporal lobe dysfunction in schizophrenia, together with an association between left-handedness and lengthy maternal labour, suggestive of birth injury, while left-handedness and crossed dominance have been associated with early onset, inferior social competence, more negative symptomatology, increased ventricular-brain ratio and poor performance on neuropsychological tests.[115]

Schizophrenics, too, show a greater likelihood to be born in the months from December to early Spring: Shur and Hare (1983) found this,[116] while O'Callaghan *et al* (1991) found a 9% excess in their sample of winter birth schizophrenics, although this was true only of patients without a family history of schizophrenia. They cite several studies which found on cranial computerised tomographic scans that there were more structural brain abnormalities in schizophrenics born in winter and early spring than in those born at other seasons, together with other studies linking prevalence of diseases such as diphtheria, pneumonia, measles, polio, and Zoster varicella to births of schizophrenics. They mention nutritional deficiencies as a possible contributing factor and note that in Sweden the seasonality effect dropped away after the introduction in 1940 of Vitamin K prophylaxis.[117]

Kendell and Adams (1991) studied a Scottish population of nearly 14,000 schizophrenics, coming to the conclusion that February, March, April and May were the months in which an excess of schizophrenics were born, linking that to unusually low temperatures six months prior, when viral infections were most

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[113] Dellatolas, G., Curt, F., and Lellouch, J., Note: Birth Order and Month of Birth are not related with Handedness in a Sample of 9370 Young Men, **Cortex**, 27, pp. 137-140, 1991.

[114] Manoach, D.S., Maher, B.A., and Manschreck, T.C., Left-Handedness and Thought Disorder in the Schizophrenias, **Journal of Abnormal Psychology**, Vol. 97, No. 1, pp. 97-99, 1988.

[115] Castle, D.J., Murray, R.M., Editorial: The neurodevelopmental basis of sex differences in schizophrenia, **Psychological Medicine**, 21, pp. 565-575, 1991.

[116] Shur, E. and Hare, E., Age-Prevalence and the Season of Birth Effect in Schizophrenia: A Response to Lewis and Griffin, **Psychological Bulletin**, Vol. 93, No. 2, 373-377, 1983.

[117] O'Callaghan, E., Gibson, T, Colohan, H., Walshe, D., Buckley, P., Larkin, C., and Waddington, J., Season of Birth in Schizophrenia: Evidence for Confinement of an Excess of Winter Births to Patients Without a Family History of Mental Disorder, **British Journal of Psychiatry**, 158, 764-769, 1991.

likely.[118] They advance the latest version of the viral infection theory of schizophrenia, where such infection either in the foetus or the new-born baby causes damage to the brain which leads to schizophrenia. Interestingly, in their sample there was further evidence that there is not only a month by month difference in birth of schizophrenics, but also a year by year difference: there are fewer than expected born in the years 1935, 1941, 1942, 1943, 1947, and 1958, while there are more than expected born in the years 1925, 1945, 1952, and 1953. The years of greater risk may be ones in which temperatures were lower than normal six months before birth and in which there may have been high influenza or other viral infection levels then, as well. The third month of pregnancy is especially dangerous for the foetus, Kendell and Adams citing maternal rubella as one first trimester disease which can cause brain damage.[119] They admit that it has been established beyond doubt by twin, adoption and family studies that the main determinants of schizophrenia are genetically transmitted; however, although this may be one, it is not necessarily the only aetiology for schizophrenia.

Most recently, Prof. Robin Murray of the Institute of Psychiatry, told the annual meeting of the Royal College of Psychiatrists in Brighton that in the spring following the Asian flu pandemic of the winter of 1957 there had been a sharp rise (an 88% increase) in the number of babies born in England and Wales who went on to develop schizophrenia. The same pattern of Asian flu as schizophrenogenic was traced through outbreaks going back to 1939; he places the most damage to the foetal brain as taking place in the fifth to seventh months of pregnancy. The spring of 1947 was another period prior to which Asian flu had been pandemic, as was the case with 1944, 1951, 1953 and 1959. It may be noted that these years do not really accord with the ones cited by Kendell [above]. Professor Murray goes on to theorise that the five-times higher incidence of schizophrenia among Afro-Caribbeans in this country is due to lower hereditary immunity to viral infections encountered in a much colder land. Influenza is not endemic in the Caribbean.[120][121] Earlier, Professor

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[118] Kendall, R.E., and Adams, W., Unexplained Fluctuations in the Risk for Schizophrenia by Month and Year of Birth, **British Journal of Psychiatry**,158, 758-763, 1991.

[119] **Ibid,** p.763.

[120] Rees, J., 'Flu is clue to brain illness', **Daily Telegraph**, 3/7/91.

[121] Eagles (1992) has gathered research together to support the theory that pre-natal infection with polioviruses contributes to the subsequent development of schizophrenia, pointing to increased rates of schizophrenia among West Indian immigrants: first-generation immigrants from the Caribbean are less likely to have immunity to polioviruses than are members of the native-born population, producing an increased frequency in their children due to intra-uterine infections. He cites evidence to show that first admissions with schizophrenia in England and Wales have fallen by around 50% since the mid-1960s, as have they in Scotland, Denmark, and New Zealand, representing perhaps a genuine decline in the incidence of schizophrenia. He theorises that if polioviruses eventually produce some forms of schizophrenia, the immunisation programmes against polio which have proved so successful have indirectly reduced the incidence of schizophrenia, as well. Unlike the other infectious agents, polioviruses peak in the late summer and early autumn, during the first and second trimesters of foetuses born during the first four months of the following year, so neatly accounting for the seasonality

Murray had told the British Association for the Advancement of Science that late winter birth children who later went on to develop schizophrenia had an area near the hippocampus where the pre-alpha nerve cells were abnormal, nerve cells which, during embryonic development, should have migrated from the inside of the brain to the outer edge but which had managed to travel approximately 80% of the way. This occurs during the final trimester of pregnancy, or is just postnatal, and is in addition to the findings that schizophrenics often had brain ventricles larger than normal, and hippocampi which were smaller.[122] Most recently (1992), Gupta and Professor Murray looked at the World Health Organisation data on schizophrenia and found that there was a positive correlation between morbid risk of schizophrenia and lower ambient temperature in various geographical locales.[123] Sham, O'Callaghan, Takei *et al* (1992) examined the relationship between the dates of birth of schizophrenic patients to hospitals for the first time between 1970 and 1979 and the occurrence of influenza epidemics between 1939 and 1960; they found that exposure to influenza epidemics between the third and seventh month of gestation is associated with schizophrenia in adult life. Maternal viral infection may well be an important cause of schizophrenia, they say, while influenza may decrease appetite and cause inadequate nutrition; urbanisation in the 19th century increased the likelihood of such epidemics, as viral conditions of all sorts are more prevalent in overcrowded conditions. Mothers with young children suffer more viral infections. Schizophrenia is more common in economically deprived, overcrowded urban areas, in the younger members of large sibships, and has increased in being reported throughout the 19th century.[124]

More recently, Sacchetti, Calzeroni, Vita *et al* (1992) report that CT scans of 206 schizophrenics and 107 patients with major affective disorders showed that those schizophrenics born between December and April, when compared with schizophrenics born at other times of the year, had increased chances of ventricular enlargement (but not for cortical atrophy), particularly for those without a family history of schizophrenia. No such association was found for the affective disorder patients.[125] Indeed, Watson, Tilleskjor, *et al* (1984) had already looked for the birth seasonality effect in neurotics, alcoholics, and those suffering from affective disorders, and personality disorders, finding no significant effect.[126] Pulver, Liang,

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effect[Eagles, J.M., Are Polioviruses a Cause of Schizophrenia ? **British Journal of Psychiatry,** 160, pp. 598-600, 1992].

122 Schoon, N., Illness during pregnancy may cause schizophrenia in child, **Independent**, 23/8/90.

123 Gupta, S., Murray, R.M., The Relationship of Environmental Temperature to the Incidence and Outcome of Schizophrenia, **British Journal of Psychiatry,** 160, pp. 788-792, 1992.

124 Sham, P.C., O'Callaghan, E., Takei, N., Murray, G.K., *et al,* Schizophrenia Following Pre-natal Exposure to Influenza Epidemics Between 1939 and 1960, **British Journal of Psychiatry**, 160, pp. 461-466, 1992.

125 Sacchetti, E., Calzeroni, A., Vita, A., Terzi, A., *et al*, The Brain Damage Hypothesis of the Seasonality of Births in Schizophrenia and Major Affective Disorders: Evidence from Computerised Tomography, **British Journal of Psychiatry**, 160, pp. 390-397, 1992.

126 Watson, C.G., Tilleskjor, C., Kucala, T., and Jacobs, L., The Birth Seasonality Effect in Nonschizophrenic Psychiatric Patients, **Journal of Clinical Psychology**, Vol. 40, No. 4, July, 1984.

Brown *et al* (1992) looked at the first degree relatives of 381 schizophrenics for any evidence of increased risk, reporting that the relatives of probands born in the months of February to May had the highest risk, the relatives of female probands having approximately seven times the risk for relatives of probands born in other months. For male probands the risk was similar for their relatives, but specific to those relatives aged under thirty years. It may be, they conclude, that a group of individuals at an increased risk of developing schizophrenia because of genetic background may also be more vulnerable to a seasonally varying factor which further increases their risk.[127] This is similar to the conclusion reached by Baron and Gruen (1988), whose study of 88 schizophrenics found an increased risk for first-degree relatives of winter and spring born patients, the morbid-risk data supporting a 'stress-diathesis' hypothesis, whereby environmental factors such as a seasonally varying viral insult interact with genetic vulnerability to increase risk for schizophrenia.[128] If the supposed polygene for schizophrenia, with a lesser genetic predisposition for the disorder, is to be found in the relatives of sufferers, perhaps the late-winter/early-spring born schizophrenics represent the greater genetic predisposition, with the most intense concentration of those pathological genes and a consequent higher than usual concentration of them in their relatives.

Multiple sclerosis has been linked with viral infection and geographical location: Derek Gay *et al* published in the ***Lancet*** an analysis of general practice records which showed that the rate of chronic sinusitis was significantly greater in 92 patients with multiple sclerosis than in matched controls (p<.0.0001). Multiple sclerosis and chronic sinusitis were also significantly associated in the timing of attacks, the age at which patients suffered such attacks, and in the seasonal pattern of attacks. Second and subsequent attacks of sinus infection peak in March, while the earliest recorded attacks peak two months earlier; sinusitis preceded multiple sclerosis attacks by one month throughout. An immunological defect was theorised, the sinus infection (or catarrh, or tonsillitis) producing damage to the tissues of the sinus, through which bacteria could infiltrate to the brain fluid, setting the immune system into perhaps too efficient action, in that it may attack the myelin sheathing of the nerves with cytokines, proteins which normally destroy the proteins of antigens. Gradual destruction of the myelin sheathing is what occurs in multiple sclerosis. Dr. Gay admits that there must be a predisposition toward developing multiple sclerosis, otherwise we would see many more sufferers than we now do; brothers and sisters of multiple sclerosis sufferers are more likely to develop the disease than others. Colds and influenza are more likely the further North one goes-and so is multiple sclerosis: in the tropics multiple sclerosis is almost unknown; around the Mediterranean multiple sclerosis rates are around 30 cases per 100,000 people;

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[127] Pulver, A.E., Liang, K-Y.,Brown, C.H., Wolyniec, P., McGrath, J., et al, Risk Factors in Schizophrenia: Season of Birth, Gender, Family Risk, **British Journal of Psychiatry**, 160, pp. 65-71, 1992.

[128] Baron, M., and Gruen, R., Risk Factors in Schizophrenia: Season of Birth and Family History, **British Journal of Psychiatry**, 152, pp. 460-465, 1988.

further North, in Europe, the rate rises to 50 per 100,000, reaching a peak in the Orkneys of around 300 cases per 100,000, the highest rate in the world. Afro-Caribbeans brought up in North America or Europe have a higher incidence than those living in Africa, but still retain a lower incidence than Caucasians.[129][130] Colds and influenza occur most frequently in the first quarter, when bodily resistance is lower after months of winter. Life expectancy is higher in the South: the death rate in the North is 13% higher for men than in the South, and 12% for women; death rates were generally lowest in the South-West, the warmest part of the UK.[131]

Not unconnected was the recent claim by Professor John Warner, a child care specialist at Southampton University speaking at the launch of the British Allergy Foundation, that couples should aim to have their children between December and February to reduce the risk of babies developing hay fever, asthma, and other allergies. He said the number of allergy sufferers is rising by 5% per year. The months from February to May are likely to be the prime time for the initial development of allergies, when exposure to high pollen counts and house dust mites coincides with the critical first few months of life.[132]

Going south to the Antipodes, Henderson *et al* (1991) report that there is no relationship of incidence of Alzheimer's Disease with season or month of birth; they conclude that this may not hold true for climates associated with higher latitudes.[133] Theirs was a study responding to that of Philpot *et al* (1989), where it was observed that there was a significant excess of first quarter births among British Alzheimer's Disease patients as compared with the expected birth rates derived from an age-matched census sample. Those patients with no family history of dementia contributed all the excess. They cite other studies where a similar first quarter effect has been found for yet more disorders, including Parkinson's Disease (high birth rate month= May).[134] Autism, too, has been studied in the light of season of birth: Bolton, Pickles, Harrington *et al* (1992) report that in a study of 1435 autistic individuals no consistent monthly trend could be found, although a national sub-sample within the overall sample seemed to suggest a March-May effect.[135]

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129 Gay, D., Dick, G., and Upton, G., Multiple sclerosis associated with sinusitis: case-controlled study in General Practice, **The Lancet**, 815-819, 12/4/86.

130 Hall, C., MS theory comes in from the cold, **The Independent**, 7/11/90.

131 **Mortality Statistics: Area**, 1988, H.M.S.O.

132 Anon., **Independent**, 27/6/91.

133 Henderson, A.S., Korten, A.E., Jorm, A.F., McCusker, E., Creasey, H., and Broe, G.A., Season of birth for Alzheimer's disease in the Southern Hemisphere, **Psychological Medicine**, 21, 371-374, 1991.

134 Philpot, M., Rottenstein, M., Burns, A., and Der, G., Season of Birth in Alzheimer's Disease, **British Journal of Psychiatry**, 155, 662-666, 1989.

135 Bolton, P., Pickles, A., Harrington, R., *et al*, Season of Birth: Issues, Approaches and Findings for Autism, **Journal of Child Psychology and Psychiatry**, Vol. 33, No. 3, pp. 509-530, 1992.

Fourie (1985) found that in South African women temperature at time of birth had an effect on personality, with the most introverted women being born in the winter and the most extroverted in the summer.[136] 154 German women showed no such seasonality of personality, however,[137] while Russell and Wagstaff (1983) had found no relationship for extroversion/neuroticism scores on the Eysenck Personality Inventory with month of birth/astrological sun sign.[138] Entering further into such areas, there have been other efforts to link measures of personality with astrological signs. Stack and Lester (1988) found that suicide ideation was significantly linked to being born under Pisces; in both the Greek and Indian interpretations of astrological Sun sign/personality linkages it is said that Pisceans will live lives characterised by various kinds of losses. Pisceans are born in February and March.[139] The Gauquelins have spent long years researching such linkages, although discounting traditional astrology. They found what they call "the Mars effect", where people born under Mars (typically Arians) are likely to be eminent in sport and be extroverts.[140] In Michel Gauquelin's obituary notice in the **Independent** of 20/6/91, Hans Eysenck was most supportive of such claims, saying only that there was as yet no good theory to account for Gauquelin's findings. In the book by Eric Jacobs and Robert Worcester, **We British: Britain under the MORIscope,** (Weidenfeld and Nicolson, London, 1990), written around the results of a large survey (N=1458) of British attitudes and types, it was observed that Aries, Leo, Virgo, Scorpio, Sagittarius, and Capricorn each have 9% of the sample; Taurus, Gemini, Cancer, and Pisces each claimed 8%, while Aquarius had 7%, and Libra 6% only. They theorise that sexual intercourse is less popular in cold January and February, and more popular in March and April, so producing the slight imbalance in numbers between signs. Most recently (1992), Professor Robin Murray's co-writer, Sunita Gupta, has published findings which **do** support both Fourie and a link between personality and season of birth: in a sample of 125, summer-born people had the highest scores on extroversion, neuroticism, impulsiveness, and venturesomeness scales, while a further thought-provoking finding was that summer-borns most often had blood-group O+, while winter-borns most often had blood-group A+; B+ individuals are most frequently born in autumn, while the possessors of blood group AB+ are most frequently born in spring.[141] The precise significance of the latter finding is difficult to ascertain;

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136 Fourie, D., Geophysical Variables and Behaviour: XXIV: Seasonal Factors in Extraversion, **Psychological Reports**, 56, 3-8, 1985.

137 Hentschel, U., Kiessling, M., Season of Birth and Personality: Another Instance of Noncorrespondence, **The Journal of Social Psychology**, 125(5), pp. 577-585, 1985.

138 Russell, J., Wagstaff, G.F., Extraversion, neuroticism and time of birth, **British Journal of Social Psychology**, 22, pp. 27-31, 1983.

139 Stack, S., and Lester, D., Born under a Bad sign? Astrological sign and Suicide Ideation, **Perceptual and Motor Skills**, 66, 461-462, 1988.

140 Gauquelin, M., Is there a Mars Effect?, **Journal of Scientific Exploration**, 2, 29, 1988.

141 Gupta, S., Season of birth in relation to personality and blood groups, **Personality and Individual Differences**, Vol. 13, No. 5, pp. 631-633, 1992.

nevertheless, it is further evidence that small but actual physical differences may be found between individuals born at different times of the year.

Aries runs through March and April; it is the martial sign, ruled by the god of war, Mars, and often people born in those months have that planet ascendant. It takes very little acumen to deduce that the controversy over "planetary influences" could dissolve if a much more earthly explanation is advanced: extroverted sports people are not known to have great intellects, and perhaps the reason they find themselves following a sporting career is that little else requiring greater intellect remains open to them. Motivation to become eminent in their field would not be lacking if that was all they could do well, harsh judgement though that may seem. It is, of course, a typical academic attitude that only when the mind is lacking will the body do; nevertheless, "brute force and ignorance" is a well-worn phrase in everyday usage, as is "strong in arm and weak of mind", folk-lore evidence of the age-old association in the minds of most people between poor intellect and bodily strength. Folk-lore often holds some elements of naturalistic observation. It may be, however, that the slight excess of births in the first quarter in most of the Northern Hemisphere is due to some extra robustness in those conceived in May and June, some bodily toughness which saw them through trials during their foetal existence which would cause the demise of a less-robust foetus conceived at another time in the year. This robust bodily strength could then in adulthood become the foundation for an athletic career. Such an explanation would hold if there was a polygenic basis for the various disorders mentioned as associated with birth in the first quarter, elements of the polygene conferring compensatory toughness and strength for lessened intellect.[142] Most of the reports reviewed here, however, make the point that the seasonal effects are found solely in patients without family histories of similar disorders.

Knobloch and Pasamanick (1958) looked at a sample of 5,855 first admissions to a school for children with mental deficiency and found that births in the months of January, February and March were significantly more common than births in the months of July, August and September.[143] Barnsley and Thompson (1985) report that approximately four times more players in the Canadian professional hockey leagues were born in the first three months of the year than were born in the last quarter.[144] Are sports people really less intelligent? Are they like that because they have been born, and have been in the womb, during the times of the year when all the worst influences, hormonal, viral, allergic, are at their strongest? Do all these factors combine to reduce the brain-power of first quarter babies? It would be a

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142 Wolf-Klein, G.P., Silverstone, F.A., Brod, M.S. *et al*, Are Alzheimer patients healthier? **Journal of the American Geriatrics Society**, 36, 219-224, 1988.

143 Knobloch, H., and Pasamanick, B., Seasonal variations in the births of the mentally deficient, **American Journal of Public Health**, 48, 1201-1208, 1958.

144 Barnsley, R.H., Thompson, A.H., and Barnsley, P.E., Hockey success and birthdate: The relative age effect, **Canadian Association for Health, Physical Education and Recreation**, 51, 23-28, 1985.

sweeping generalisation, indeed, and based on evidence which is not consistent-there have been several studies which have failed to find such correspondences-but nevertheless, coming from disparate areas, evidence is accumulating that one should not expect high intellectual achievement in early or later years from those Northern Hemisphere individuals born in the first quarter of the year, and indeed, may well have pessimistic feelings about their mental and physical health in general.

As if the various factors possibly afflicting the foetus conceived in May, June or July as detailed above are not enough, a further deleterious influence has been identified: in July of 1991, the Medical Research Council presented evidence that neural tube defects are partly the result of a lack of nutrients during the earliest stages of pregnancy; in a study of 1800 women who gave birth to babies with neural tube defects, such as spina bifida, or anencephaly, it was found that the risk of having another similar child was reduced by almost three-quarters by taking folic acid, a nutrient found in green vegetables. Spina bifida occurs most often in the lowest socio-economic groups. Poor nutrition is found most often in the working class areas, predominantly in the North and West of England, North Wales, and some parts of Scotland. Professor David Barker of the MRC's Environmental Epidemiology Unit at Southampton University claims that poor nutrition of the foetus may explain why mortality is higher in those areas, too: if the pregnant mother eats poorly, then her foetus is fed badly, will have a low birth weight and a small head circumference, will not thrive as an infant (in extreme cases perhaps having cerebral palsy or blindness), and will have a shorter adult life.[145] Professor Barker believes 8/10% of the population fail to reach their full genetic potential because of inadequate maternal diet.[146] Sir Donald Acheson, until recently the Government's Chief Medical Officer, has stated that lower consumption of vegetables in the North of England and Scotland account for the high local rates of heart disease in adults, linked to low birth weights. Mothers must eat more vegetables, cereals and fruit.[147]

How does poor nutrition disproportionately affect babies born in the first three or four months of the year? Clearly, all the best foods are more expensive, and scarce in winter; the poor cannot afford to include in their diet such items as fresh fruit and vegetables when prices rise beyond their budget during winter time. It is possible

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145 The worst area known is that of the Grangetown Estate, Teeside, where life expectancy is ten years below the national average, there is a high incidence of spina bifida, and women are 400 times more likely than the norm to die of lung cancer or other respiratory diseases. There is a high proportion of one-parent families, and local schools have inhalers ready for children from Grangetown who suffer asthma attacks during class. Industrial pollution seems to cause such increased incidences of childhood asthma, and the whole Cleveland area is polluted by an ICI chemical factory and a British Steel works, probably making it the most polluted area of Western Europe. Report by Paul Brown, **The Guardian**, 22/8/90.

146 Matthews, R. Putting Bounce into Baby, **Daily Telegraph**, 2/9/91.

147 Pallot, P., Diet clue to North's heart disease rate, **The Times**, 5/9/91.

that having become accustomed to the more satisfying taste of cheaper fat-bearing foods, low-income mothers pregnant during the winter months are more likely to eat what they like than what may be good for their unborn children, and which may be beyond their pocket, as well. The dramatically increasing numbers of single-parent families with low earning capacity will only serve to exacerbate this problem. Further, the increased numbers of babies born in the first quarter may reflect the greater fertility and fecundity of social classes C, D and E, whose children may form the larger part of that "bulge".

Another reason for suspecting that all these disadvantageous factors may be found in the sports person is that sport is one traditional route out of poverty in our culture: when education has failed a person, either crime or sport is often chosen as a way toward riches. All these converging elements, season of birth, maternal diet, hormonal uterine environment, viral infection of the mother or foetus, temperature, geographical location, familial income level, may well produce the high-achieving sports person with a strong motivation, if not a great intellect. Sebastian Coe, PhD, is, of course, just one exception to this rule.

Are there any areas other than crime or sport in which someone, for whatever reason less able mentally than others, may do well, thrive, and gain the emotional and possibly financial satisfaction we all crave? The visual arts are another way, as is music, drama, and dance, all, together with sport, well-known avenues of escape from a poor background and educational failure. "Failure", of course, is a relative term: those whose cognitive skills do not measure-up to the ideals of Western culture today are considered failures, such as the dyslexic. High or low intellect is something measured by standards in verbal-sequential abilities, "school skills" in reading, writing and arithmetic. Measured by these standards, many sports people may well be considered "dim", but they may often retire from their chosen sport having achieved more fame, wealth, and happiness than any academic in any University.

Lamarckian Inheritance, Stress, And Metal Workers

The number of non genetic factors apparently involved in the determination of laterality is so large that no purely genetic theory would be able to deal with them, say Geschwind and Galaburda. Nevertheless, the strangely Lamarckian effects of the predominately maternally-derived cytoplasmic genes in the production of structural proteins may explain the finding that left-handed mothers have more left-handed children than left-handed fathers, that handedness may be predicted from that of the maternal grandparents, and that mothers who have had a neural tube defective child by one father are more likely than control mothers to have another by a second husband. The elevated level of left-handedness in both monozygotic and dizygotic twins *and* their first degree relatives (double that of parental siblings) has no simple genetic explanation. There is, in addition, a higher rate of dyslexia among twins. In rats, females stressed during pregnancy often produce demasculinised male offspring, the stress reducing the testosterone levels of the foetal environment; in a strange, Lamarckian fashion, the un-stressed daughters of such stressed mothers will tend to have demasculinised male offspring, as well! Permanent changes in perhaps the non-nuclear mitochondrial genes may therefore result in permanent changes in the metabolism of the following generation.

A disproportionate number of both mothers and fathers of autistic children are reported to have had contact with chemicals; exposure of the father to chemicals may simply modify the genes transmitted to the offspring, perhaps by a process called "methylation", and thus alter the environment of the foetus. It would follow that fathers who pursue careers such as industrial chemists, civil engineers, or silver- or gold-smiths would be more likely to be the producers of children with learning disabilities and, possibly, anomalous and exceptional talents. Havelock Ellis, in his previously mentioned early study of British genius, found that there was a very notable predominance of craftsmen in the parentage of painters, to such an extent that, whereas they constituted only 9.2% among the fathers of his group of eminent persons generally, they constituted nearly 35% among the fathers of painters and sculptors.[148] The influence of the parental careers and talents may prove strong in cognitive test scores, although deciding between their biological or environmental effects would be impossible.

Scotland, West Africa, And The Talented Stutterer

As there are very high rates of dizygotic twin births in Northern Ireland and Scotland, together with a high rate of neural tube defects, such as spina bifida,[149] [150] it may be predicted that in those geographical areas there ought to be a higher number of the associated anomalously talented children than elsewhere in the United Kingdom. The only other area where twinning is more common, report Geschwind and Galaburda, is in West Africa, particularly among the Yoruba in the vicinity of Ibadan, where the incidence is one in 18 births. Stuttering is three times as common among school-children in West Africa than it is in school-children in the United States, while American blacks, mostly of West African origin, have higher stuttering rates than whites. It would seem likely that in blacks of West African origin one would find elevated levels of left handedness, learning disabilities, anomalous brain dominance, and the associated exceptional talents. In this the conventional blond, blue eyed Northern European resembles more closely

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[148] cited in Appendix 2, Macfarlane-Smith, I., **Spatial Ability: Its Educational and Social Significance**, London: U.L.P., 1964.

[149] There is a connection between high lead concentration in Scottish water and malformation of the CNS, such as in spina bifida. Hyperactivity is associated, as well, with high blood lead levels. See Morgan, B.L.G., Effects of Hormonal and other Factors on Growth and Development, Chapter 4 in **Brain and Behavioural Development: Interdisciplinary Perspectives on Structure and Function**, Surrey University Press, Blackie, 1982.

[150] There is a high rate of twinning in the parents of spina bifida children, as well.

the West African black, whereas research would lead us to associate the Japanese with the Southern European, in that both ethnic groups demonstrate *lowered* levels of all the pathologies and dominances noted for the first group. Lansky, Feinstein, and Peterson, in the previously quoted study on handedness, found that left-handed and left-mixed individuals were found with raised frequency among young, male blacks.[151] It is possible that there will be more children with learning disorders, left handedness, neural tube defects, etc. in Scotland than, for example, in the Midlands, and more anomalously able children in non-academic areas of skill, as well. Given the present low numbers of West African-origin blacks in Scotland, it would seem these will play little part in this study; only if such overseas students at Edinburgh University were studied would they play a larger part in the research. As a general conclusion, however, hyperactives and people with speech impediments may well score lower than others on cognitive tests.

President Garfield, Independent Hemispheres, Mirror Writing And Cancer

Some childhood dyslexics read better in a mirror or with a book held upside down, so that the print is both inverted and reversed. There are left-handers who are able to write in mirror fashion, as well;[152] the most famous example in history being, of course, Leonardo da Vinci, whose notebooks were written in inverted and reversed fashion. The occasional left-hander is even able to write a sentence with one hand in one direction and another sentence in the other direction at the same time. The American President, James Garfield, who was left-handed, was apparently able to do this in two different languages![153] A female blue-eyed, blond, Scottish left-handed child was able to write at three-and-a-half years, commencing her sentences with the left hand, changing hands at mid-page, and completing the sentence with the right hand. These abilities may derive from the lack of interference effects between the two hemispheres due to a possible defect in callosal connectivity, a defect common in dyslexics but one not necessarily always accompanied by dyslexia. This female in late adolescence became a national-level fencer, who trained for accuracy (and with a very high success rate) by thrusting with her foil into the middle of a wedding ring swinging like a pendulum on a thread.[154]

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151 Lending further support to the thesis that high ability will be found among left-handers were their further findings that more left-handers and the left-mixed handed were to be found in higher education and in white-collar jobs. Jews, who represent not only a religion but also a race, and are well-known to produce individuals of the very highest intellectual ability more often than most other ethnic groups, were found to have a higher incidence of left-handers and left-mixed handers than Protestants, Catholics, and nonbelievers.

152 There is at present a blue-eyed, blond art therapist postgraduate student in the Department of Psychology, University of Edinburgh, who mirror-writes easily and fluently with her right hand; she has some problems with writing identified as typical of dyslexics.

153 The present writer was once employed by a middle-aged, dark-haired, dark-eyed office manager of possibly German-Jewish extraction who was able to duplicate this feat; it may not be as rare, therefore, as has been supposed.

154 Personal communication from her father.

The eight year old son of an undergraduate student is left-handed, asthmatic, has a squint (largely corrected), has had some difficulty with writing, has a partial speech impediment (pronunciation of "r"s), and possesses dark blue eyes, and mid- to light-fair hair. He appears to have high spatial ability, shown by very advanced use of perspective in architectural drawings [see **FIGURE ONE**], and the assiduous copying of "*Ghostbusters*" characters from comic books, together with an unusual awareness of ball-placement in golf.

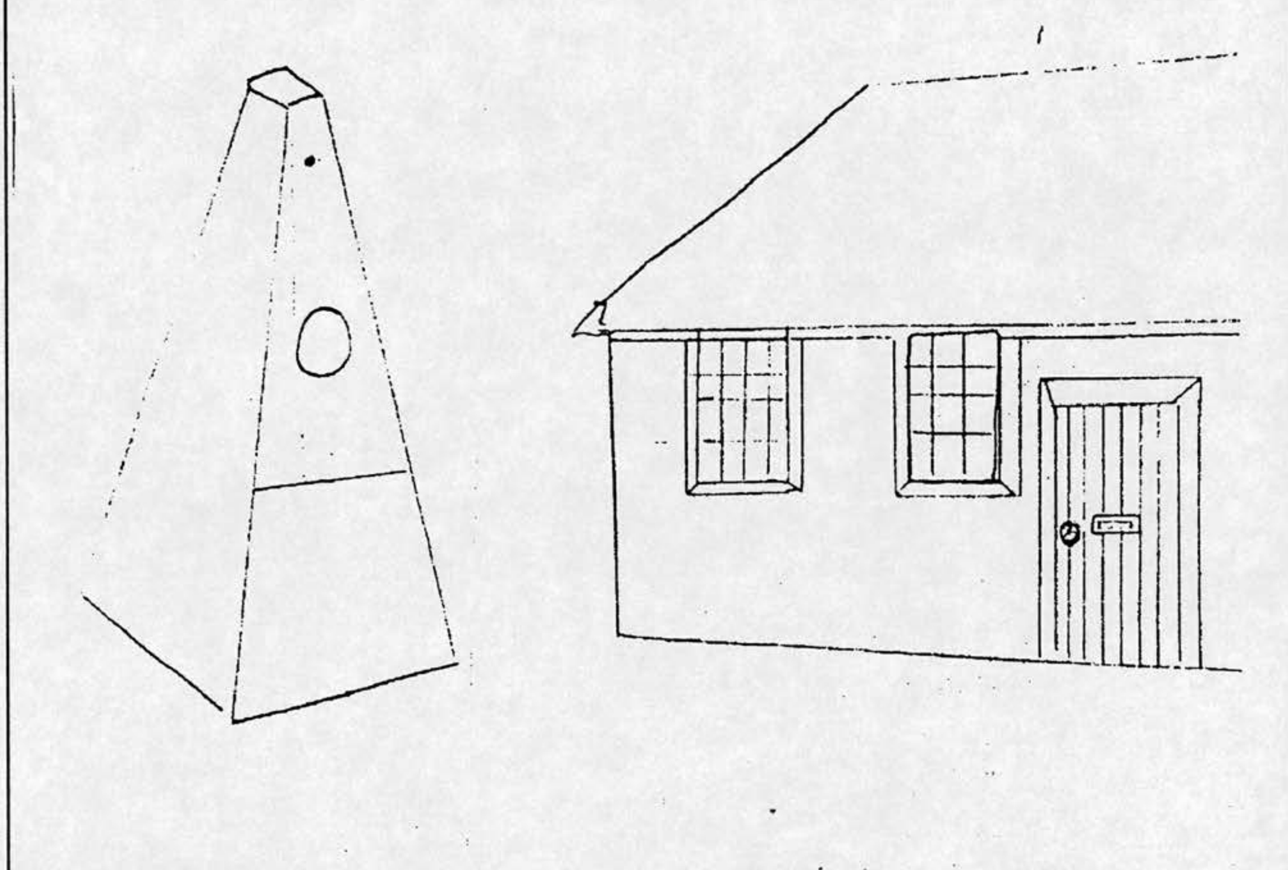

FIGURE ONE: PRECOCIOUS 8 YEAR OLD'S PERSPECTIVAL DRAWINGS

Nine-and-a-half pounds in weight at his Caesarean birth, he has shown very high mathematical ability, and has been judged by his teachers to be advanced by one year over the other children of his age at school. Hyperactivity and associated mental disturbances have been noted when he drinks "Coke" or any other fizzy drink. His mother has low level red/green colour blindness, as the carrier, while his is the full-blown variety. His mother's father was an architect, while his father's father was an engineer. His mother's mother has noticeable learning/reading difficulties. This concatenation of pathologies and associated familial and personal characteristics seems supportive of the thesis; unfortunately, permission to test either the mother or son was not given.

It may be that a condition for consciousness is the separation of neural events, allowing them some independence in the two hemispheres. Mild degrees of diminished fusion may lead to the formation of superior individuals who may be closer to the goal of optimal cognitive capacity, or so said Geschwind, going further to say:

> The capacity of each half brain to control its motor functions relatively independently may be one of the factors accounting for the high rate of NRH among...very successful athletes, and in fields such as architecture and the other visual arts.[155]

A price may sometimes have to be paid for exceptional talent: there is a high rate of lymphoid malignancies in autoimmune disorders; it might therefore be expected that there would be an elevated rate of such malignancies in anomalously dominant, learning deficient and/or highly talented, left-handed individuals and their families. Celiac disease, frequently found in autistic children, has a higher than usual death rate from all malignancies, due to an increased number of lymphomas, together with a higher rate of left-handedness. Both mothers of autistic artists Nadia Chomyn and Richard Wawro died early of cancer, while Richard was diagnosed as having lymphosarcoma at five years old (successfully treated).

THE ARTIST

It appears that our culture has ceased to value the artist very highly; indeed, the attitude of many seems to be that someone who uses brushes, paints, charcoal, or pen to make paintings or drawings, either representational or non-representational, is about as useful as a wheelwright, a fletcher, or the man who used to shovel manure behind horses. Why get dirty and go through long and arduous training in order to produce images when photography or computer graphics can produce them in a fraction of the time, cleanly and reliably? An Apple Mac does not have artistic temperament, haggle over the price, or run off with the model.

Government schemes in education emphasise the sciences, making them core courses, de-emphasising the arts in general, making them optional. Schools have long since ceased to have art teachers and now make do with "art specialists" who visit from time to time, having to spread their expertise over large geographical areas and great numbers of pupils, with a consequent loss of ability to give

[155] p.544, Geschwind and Galaburda, Cerebral Lateralization, **Archives of Neurology**, June, 1985.

individual attention. Art therapists constantly battle against lack of recognition and prejudice. It has been hundreds of years since becoming an artist was seen by parents as a proper vocation, likely to lead to respect and standing in the community. In the present climate, becoming an art student is evidence of either great courage or appalling lack of common sense.

It appears that a case could be made for identifying artists as a minority suffering quite strong discrimination-long gone is the time when Michelangelo or Benvenuto Cellini could stand up as equals with the great and powerful of their society.

How have changed social values made the artist seem an inferior being? Indeed, how much is this perceived inferiority based in objective fact, disregarding value judgements?

The personality structure of the artist, say Karnes *et al*, is lower on leadership but, as might be expected, higher on creativity than the academically gifted, lower on abstract thinking, more excitable, impatient, demanding, unrestrained, tender-minded, sensitive, individualistic, reflective, and internally restrained. Artists are tense, frustrated, driven people.[156] Piechowski, Silverman, and Falk support the excitability finding, referring to the artist's depth of feeling, especially in introverted individuals, something which sets them apart from normal society-beautiful or sad things can move them to tears; however, they have a high mean psychoticism score as well, making them solitary, hostile to others, and aggressive. Their experience of life is intense-we test the reality of their perceptions by viewing the images they create.[157]

Cross*et al* used the 16PF test to determine that artists were reserved, but dominant, assertive, self-sufficient, emotionally unstable, casual, have low super-ego strength, are suspicious, apprehensive, prone to guilt feelings, are tense and overwrought, while they show what Cattell called "autistic" tendency, hysterical unconcern, something which his research had shown over the years as highly significant in differentiating the creative individual. Artists are, he says, the very opposite of the successful salesman in personality type. Most studies have found high levels of anxiety in art students.[158] Earlier, Drevdahl (1956) had used the same instrument to find that artists were significantly more schizothyme, self-sufficient, withdrawn, sophisticated, and radical than the science undergraduates. "Schizothymic"

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156 Karnes, F.A., Chauvis, J.C, and Trant, T.J., Comparison of Personality Profiles for Intellectually Gifted Students and Students Outstanding in the Fine and Performing Arts attending Self-Contained Secondary Schools, **Psychology in the Schools,** 22, pp. 122-126, April, 1985.

157 Piechowski, M.M., Silverman, L.K., and Falk, R.F., Comparison of Intellectually and Artistically Gifted on Five Dimensions of Mental Functioning, **Perceptual and Motor Skills,** 60, pp. 539-549, 1985.

158 Cross, P.G., Cattell, R.B., and Butcher, H.J., The Personality Pattern of Creative Artists, **British Journal of Educational Psychology**, pp. 292-299, 1967.

preoccupations are with things, ideas, finished products rather than people.[159] Gotz and Gotz (1979) used Eysenck's Personality Questionnaire with a group of 337 artists and sculptors, reporting that they scored lower on Extroversion and higher on Neuroticism than did controls. The artists were also higher than non-artists on psychoticism, indicating some hostility to peers, a tendency to prefer solitude, and to enjoy divergent or strange things. Gotz and Gotz suggest that there may be a tendency in artists toward schizophrenic thought disorder, and that psychoticism in conjunction with other personality traits may be the key to such artists' success.[160] Getzels and Csikzentmihalyi (1976) generally confirm most of what has already been noted concerning the nature of the artist: they are slower on performing paper and pencil tests, scoring twice as highly as the norms on tests of aesthetic judgement; holding extreme views on a range of subjects, they are single-minded concerning their art, have low economic and social values, apparently not expecting much material reward for what they do, and preferring to do it on their own. They have very similar value patterns to those of architects and, oddly, scientists; however, creativity is required by all three groups. Using the 16PF, these authors found that artists are aloof, serious, introspective, low in superego strength, intensely subjective, and imaginative, radical, and experimental. Very self-sufficient, they differ by sex, as well: the female art students are more dominant than other women of their age, while the male art students have more sensitivity and "effeminacy" than is usual in males. Effectively, artists of either sex resemble each other more closely than do normals, the two sexes' personalities converging in the artist. The authors cite Rau (1963), who found that ability in spatial visualisation is associated with imaginativeness in boys and with aggressiveness in girls. They quote Cattell's 1963 study, which established norms for creativity by using 16PF measures for aloofness, imaginativeness, and sensitivity, among others, and established that art student creativity is found in only one college (University) student in ten. This points to the unique personality configuration of the artist-they are "a breed apart".

One aspect of their personality which seems essential for creativity is naiveté: Goethe remarked that naiveté is the greatest asset of the creative person, Matisse said that it was the source of anything good he may do, while Einstein claimed that "not understanding" the old physical laws led him to challenge them with his own, a kind of naiveté. To reject the givens of the time, the artist (and, apparently, the scientist) must be prepared to be open, unspoiled, spontaneous, and free from convention. The shrewd or Machiavellian individual seems unlikely, according to these 16PF scores, to be any sort of artist. Female art students seem to treat their courses as academic, while the males treat them more as workshops. These authors found a .510 correlation ($p<.001$) for females students between art grades and academic grades, but only .240 for the males (NS). The correlations between spatial

[159] Drevdahl, J.D., Factors of importance for Creativity, **Journal of Clinical Psychology**, 12, 21-26, 1956.
[160] Gotz, D.O., and Gotz, K., Personality characteristics of professional artists, **Perceptual and Motor Skills**, 49, 327-394, 1979.

visualisation and art grades for male and female students were -.320 and .180, a significant difference, indicating that perhaps female art students, known to be less able to start with in that area of perception, are more closely graded by this quality in their work than the males, who are assumed to have good spatial ability. The authors go on to say that successful art students of both sexes have more extensive academic backgrounds, come from more stable families, and are of somewhat higher socio-economic status than those who do not succeed. Intelligence and perceptual abilities count more toward female art student success than toward that of the males, but, for both, the criteria for success is the greatest intensity of all the personality features outlined above-the more they are truly "an artist", the more they will succeed as an artist. Good academic grades in art school are significantly related to later failure as an artist ($p<.05$). Better educated parents assist in helping the artist to succeed, with the mother being especially important. Returning to the matter of spatial ability, they say:

> It is by manipulating visual forms that artists express their creativity, therefore it is quite appropriate that they should be unusually proficient in this respect. But neither spatial visualisation nor aesthetic taste have much to do with creativity. The cognitive ability to ask new questions is independent of visual skills, which if indispensable to artists, are less relevant to musicians or mathematicians. Whatever this ability consists of, we know at this point that it is unlikely to be synonymous with so-called intelligence, a quality that artists, as we have seen, do not possess to an exorbitant degree.[161]

Kay Redfield Jamison (1989) studied mood disorders and patterns of creativity in British writers and artists, finding that their rate (sample 87% male) of treatment for affective illness was strikingly high, 38%, while in the normal population the rate for bipolar and unipolar disorders is 1% and 5%, respectively. The positive point she makes about this is that what hypomania produces in enthusiasm and excess, the more critical and obsessive eye of depression may judge and edit.[162] Albert Katz (1986) looked at the relationship between creativity and cerebral hemisphericity in architects and female mathematicians (N=87), using archival data on the Street Gestalt Completion test (markedly impaired by damage to the right hemisphere, but not to the left) and the Similarities sub-test (highly impaired by left hemisphere damage, but largely spared by right hemisphere damage) of the Wechsler adult IQ test. He estimated creativity from the number of patents to the scientists, peer evaluations, and some psychometric creativity test results, together with IQ. Hemisphericity did not seem to be related to overall intelligence, but it was to some objective measures of creativity, the directions of the relationships being different for the architects and the mathematicians. He interpreted these results as meaning that creativity depends on cognitive ability in both hemispheres, and that different

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[161] Getzels, J., and Csikzentmihalyi, M., **The creative vision: a longitudinal study of problem finding in art**, New York: Wiley, 1976, p. 32.

[162] Jamison, K.R. , Mood Disorders and Patterns of Creativity in British Writers and Artists, **Psychiatry**, Vol. 52, May, 1989.

professions require a specific cognitive mode for efficient performance. The architects were highly proficient in the Gestalt Completion test, compared to the mathematicians and scientists ($p<.01$). In contrast, the scientists and mathematicians performed better on the Similarities test ($p<.01$). Nevertheless, there was an association between good performance on the creativity test and the expression of left hemisphericity, $r=-.220$ for the architects, and $-.200$ for the mathematicians, with even the number of articles and the number of pages written about the person being related to reliance on the left hemisphere: $r=-.350$ and $r=-.450$, respectively. For the architects, creativity, as estimated by a panel of architect peers, was related to left hemisphericity: $r=-.460$, although for the mathematicians and scientists right side hemisphericity was more related to quality of output: patents earned, publications, peer ratings were all related to relative reliance on right hemisphere related mechanisms. The preference for creative complexity was associated with left hemisphericity, but, once more, there was no relation found of any significance with intelligence. Closer examination of his data seemed to show that the architects were judged partly by their peers as more creative according to the extremeness of their hemisphericity, either left or right hemisphere-exceptional performance using either was evaluated highly. Katz claims that level of creativity may be predicted from hemisphericity, which accounts for some 7 to 21% of the variance in an already rather homogeneously creative group-the normal population would provide much more. He concludes that proficiency in math and science requires a Propositional or logical-analytical mode supported by left hemisphere structures, while an Appositional perceptual-holistic right hemisphere supported mode is essential for the efficient architect. In both architecture and math, high creativity would depend on equivalence of hemisphericity in the individual, access to both modes seemingly essential for the highly creative person.[163]

Supporting the above are the findings of Charman (1981) when he looked at hemisphericity in fine art and physical sciences lecturers, using a tachistoscope in a letter recall task divided by visual field: artists did seem better at processing information directed to the right hemisphere than to the left, while scientists were better in the converse manner. Artists seem to preferentially use the right hemisphere to process verbal material, a very unusual result, indeed, when normal processing patterns are recalled. Artists tended to be more efficient than scientists at processing visual material. When the same researcher looked at male fine art students and male electronic engineering students, the results of the first experiment were strongly supported, in that the fine art students were better at processing information directed at the right hemisphere than the left, while the electronic engineers were the converse. Overall, however, the engineering students

[163] Katz, A.N., The relationships between creativity and cerebral hemisphericity for creative architects, scientists, and mathematicians, **Empirical Studies of the Arts**, Vol. 4 {2}, 1986.

performed better than the fine art students, reversing the findings of the first experiment.[164]

D'Amico and Kimura (1987) found somewhat differently, when they looked at right-handed and non-right-handed Arts and Sciences students, using a verbal dichotic listening task and a variety of paper and pencil cognitive tests: Science students had better spatial abilities than the Arts students; non-right-handed Science students had better verbal ability than right-handed Science students, while non-right-handers in the Arts had less lateralisation and poorer spatial **and** verbal ability than right-handed Arts students.[165]

Using EEG asymmetry, specifically of occipital alpha, Dumas and Morgan (1975) tested male artists and male engineers on a series of tasks, including face recall, the Nebes test of part-whole relationships, counting by twos and adding number series, specific word-spotting in a boring passage, all rated on a scale of difficulty by the subject. No difference between the two disciplines was found, although the laterality of task was significantly different, linguistic and mathematical versus face recollection and Nebes test ($p<.0.005$). Curiously, they found that artists had higher average alpha amplitude than the engineers ($p<.0.05$). They observe that in their experience at other times, most people fall into the middle range of alpha amplitude, but those with very large amplitude alpha tend more often to be artists, and those with very small amplitude alpha tend more often to be technologically oriented. Engineers in this study reported that they are poor visualisers, and verbally code visual memory tasks, while the artists tended to report more global approaches to any problem, often doing arithmetic tasks using visualisation strategies; however, the EEG records show that, in fact, the engineers used their right hemispheres for the facial memory tasks, while the artists actually used their left hemispheres for the math items. The authors say that because any given individual excels in one mode does not mean that a disproportionate amount of his or her cognitive processing takes place in that hemisphere; when a person has a dominant cognitive style, they do not necessarily use one hemisphere for the tasks appropriate to the other hemisphere, but rather have differential aptitudes in lateralised functions, perhaps seeking out environments (disciplines?) in which the more developed mode is utilised more.[166]

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164 Charman, D.K., The cerebral hemispheres appear to function differently in artists and scientists, **Cortex**, 17, 453-458, 1981.

165 D'Amico, C., and Kimura, D., Different Sub-groups of Adextrals Based on Speech Lateralization and Ability Patterns, *Abstract*, **Journal of Clinical and Experimental Neuropsychology**, Vol. 9, p. 278, 1987.

166 Dumas, R., and Morgan, A., EEG asymmetry as a function of occupation, task, and task difficulty, **Neuropsychologia**, Vol. 13, 219-228, 1975.

Hermelin and O'Connor (1986), when studying a group of mathematically gifted children and a group of artistically gifted children, found that the mathematically gifted were better in solving verbal-spatial problems, while the artistically gifted were better at constructive imagination on the basis of minimal perceptual cues. Despite being of different IQ levels, both groups were equally good and superior to IQ-matched controls in a visual recognition task. Verbally-presented tasks requiring spatial reasoning were better solved by the mathematically gifted than by either other group, while the finding that the artists are able to arrive at conclusions on the basis of insufficient information, usually regarded as a sign of high general intelligence, seems to indicate in the artists, who were not superior in IQ to any of the other groups involved, a ready generation of stored visual images triggered by minimal stimuli. In the mathematically gifted children, the ability to relate spatial images to verbal propositions, and the capacity to deal with such images in a conceptualised form may be specific to those gifted in math.[167]

The hemispheres in all of us may be differentiated for processing the subject matter of art works: Zaidel and Kasher (1989) investigated this by projecting realistic and surrealistic paintings to either hemisphere via the contralateral visual half-fields, and then used such pictures with added metaphorical or literal titles, testing the relative subject memory for the various categories of paintings. There was a left hemisphere advantage for the surreal paintings, but no hemispheric difference for the realistic ones; there was a left hemisphere advantage for metaphoric titles, while if the two are added, there is a left hemisphere advantage over all for titles from the pairing surrealistic-metaphoric. The only significant right hemisphere advantage was for recalling pictures with literal titles. Incongruous concatenations of unlikely visual objects seem to be processed best in the same left hemisphere which is better able to ascribe meanings to special arrays which violate all basic rules of combination, and that includes (probably especially) verbal arrays such as the metaphor.[168] It follows that the novel or unexpected may be processed preferentially in the left hemisphere.[169]

Dudek found that architects were similar to artists in their sensitivity, high levels of emotionality, great responsiveness to colour, and sensuality, but he had distinguished between them in other areas, with the artist more likely to dehumanise Rorschach shapes, and to see human activities as painful and tense. The depression and pain found in the artist gives way in the architect to optimism

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[167] Hermelin, B., and O'Connor, N., Spatial representations in mathematically and in artistically gifted children, **British Journal of Educational Psychology**, 56, 150-157, 1986.

[168] Zaidel, D. W., and Kasher, A., Hemispheric memory for surrealistic versus realistic paintings, **Cortex**, 25, 617-641, 1989.

[169] personal communication, Dahlia Zaidel, 1989.

and pleasure in having created something useful and permanent.[170][171] The artist has been described quite often as having poor mental health: Springett and Lekarz's art students had more evidence of anxiety, insomnia, depression, and poor relationships with their parents, particularly the father.[172]

In 1974, Peterson and Lansky carried out a survey on 484 students and 17 staff members at the Department of Architecture of the University of Cincinnati, finding that the incidence of left-handedness was almost 3 times the normal among staff and 1.5 times normal in the students. Presented with tests of spatial ability, the left-handers completed their tasks perfectly, while over 50% of the right-handers made errors.[173] In a longitudinal study, Peterson and Lansky found that proportionally more left-handers (73.4%) than right-handers (62%) successfully completed their six-year Architecture course.[174]Architecture, of course, uses many of the same abilities as does the production of visual art.

Famous left-handed artists litter the history books, such as Leonardo da Vinci, Holbein, Durer, Michelangelo, Fuseli, and Landseer (all remarkably precocious).[175] Some famous artists lacked verbal skills to the point of being inarticulate, one example being Turner,[176] while, for all his inventiveness and brilliance in art, architecture and mathematics, Leonardo admitted to not being a learned man in letters.[177] Artistic ability seems to be associated with several antisocial and some almost pathological traits, together with a firm prediction that they will not score highly on any test of cognitive ability.

Eidetic Imagery And The Precocious Artist

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170 Dudek, S.Z., The Architect as Person: A Rorschach Image, **Journal of Personality Assessment**, 48, 6, 1984.

171 Dudek, S.Z., Hall, W.B., Some Test Correlates of High Level Creativity in Architects, **Journal of Personality Assessment**, 48, 4, 1984.

172 Springett, N.R., Szulecka Lekarz, T.K., Faculty differences in psychological disturbance among undergraduates on arrival at university, **British Journal of Medical Psychology,** 59, pp. 69-73, 1986.

173 Peterson, J.M., and Lansky, L.M., Left-handedness among architects: some facts and some speculations, pp.547-550, **Perceptual and Motor Skills,** 38, 1974.

174 Peterson, J.M., and Lansky, L.M., Left-handedness among architects: partial replication and some new data, pp.1216-1218, **Perceptual and Motor Skills,** 45, 1977.

175 In other arts, Goethe, Nietzsche, Beethoven, Lewis Carroll, and Charlie Chaplin were sinistrals as well.

176 His lectures to the Royal Academy as Professor of Perspective were invariably conducted with his back to the students, talking in a muffled and garbled manner to the wall upon which he had pinned his examples! p.118, Gage, J., **Colour in Turner: Poetry and Truth,** U.K., Studio Vista, 1969.

177 Sarton, G., **Six Wings: Men of Science in the Renaissance**, Bloomington, Indiana, Indiana University Press, 1957.

An aspect of precocious talent (not necessarily solely in the field of the visual arts) unmentioned by Geschwind and Galaburda (1987) is the suspected involvement of some sort of eidetic imagery, the retention or creation of an image by an individual which may be scanned by the eye as though it were a concrete object in the real world, rather than a mental construct. The vivid and detailed nature of such images has been indicated by several researchers as a possible explanation for the predominantly representational character of the anomalous art produced by savants or the precocious child artist. Siipola and Hayden,[178] confirmed the theory that eidetic imagery was more common in the retarded than in the normal, by three to one. Although their hypothesis that eidetics should be more frequently found in the brain-damaged has been challenged since, by Gray and Gummerman,[179] interest continues in this controversial ability, especially in the University of Western Australia, where researchers have found that eidetic imagery is present in some normal children, declining from a level of 10.29% at 6 years of age, to zero at 11, 12, and 13 years. It may be serving a cognitive function in young children, speculate these researchers, but decaying with age as more advanced (less primitive?) modes of thinking become available. No gender relationship has been found.[180] There is a possibility that eidetic imaging may be a primitive thought process, originating in the right hemisphere, found early in the development of many children, but which is overwhelmed and lost under the demands of becoming literate and the consequent greater dependence on left hemisphere processing.

Gustave Dore, the French 19th century illustrator, was able from the age of four to preserve images in his memory to draw later, in great detail; this is a characteristic found in Richard Wawro, Stephen Wiltshire, Nadia Chomyn, and in all the autistic artistic children discovered by Lorna Selfe,[181] together with David Downes and Mark Fuller, the children found by Dr Sheila Paine,[182] and in many other famous artists: in 1849 Turner was still painting subjects from memory alone of an Italy last seen 20 years before.

The Sex Hormone Levels Of Architects

Gordon and Lee (1986) used the Cognitive Laterality Battery to investigate the relationship between blood gonadotrophin levels and lateralisation. They found that in males levels of concentration of FSH are negatively correlated with visuo-spatial functions, although LH tends to correlate positively with word fluency,

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178 Siipola, E. M., and Hayden, S.D., Exploring Eidetic Imagery among the Retarded, pp. 275-286, **Perceptual and Motor Skills**, 21, 1965.

179 Gray, C.R., and Gummerman, K., The Enigmatic Eidetic Image: A critical examination of Methods, Data, and Theories, pp.383-407, **Psychological Bulletin**, Vol. 82, No. 3, 1975.

180 Richardson, A., and Harris, L.J., Age Trends in Eidetikers, pp.303-308, **The Journal of Genetic Psychology**, 147(3), 1986.

181 Selfe, L., **Normal and Anomalous Representational Drawing Ability in Children**, London: Academic Press, 1983.

182 Paine, S., **Six Children Draw**, London: Academic Press, 1981.

verbal and sequential skills. In females, FSH and LH both correlated positively with word fluency and FSH correlated negatively with one visuo-spatial task after the effects of estradiol and progesterone were partialed out. These findings are consistent with the conception that the superior performance by females on verbal tasks and males on visuo-spatial tasks is hormonally based.[183] An implication of this finding is that the right hemisphere cognitive profile found for both architects and engineers may be attributed to some extent to lower than normal sex hormone levels. This is contradicted by the often-observed fact that low testosterone males (hypogonadal), and Turner's Syndrome females, usually have a high verbal and low spatial ability profile. It may be that there is an optimum level of male hormones for high spatial performance: too much and performance in that area falls away, too little and a similar effect occurs, another appearance of the previously mentioned non-linear upturned U-shaped curve.

Homosexuals, The LH Response, And An Artistic Career

Dorner *et al* [184] tested a theory concerning homosexuality which involved administering oestrogen to what they called "primary" homosexuals, those in whom androgen deficiency in the first hypothalamic organisation phase of foetal development had so altered the brain structure that they possessed what were in effect female brains in male bodies. Animal studies indicate that stressed pregnant mothers often produce homosexual offspring; such stress could interfere with normal uterine hormonal levels, by the possible production of antibodies to testosterone by the mother. The predicted effects were observed: 13 out of 21 "primary" male homosexuals reacted to the oestrogen in a typically female fashion, by producing a LH response. Of 25 "secondary" male homosexuals, thought to have become so mostly through psychosocial influences, only 2 showed this effect. There may be a connection here with the often-observed phenomenon that male homosexuality is very common in the visual and dramatic arts, where spatial ability, enhanced colour sense, emotional responsiveness, and the capacity to express emotions with fluency are essential. These are all right hemisphere based abilities. MacCulloch and Waddington (1981) reviewed the classification and aetiology of male and female homosexuality, indicating abnormalities in foetal exposure to hormones as predisposing to deviant sexuality, very similarly to Geschwind and Galaburda.[185] Hormonal and *immune system* differences may be indicated by not only the raised numbers of left handers recently found by Lindesay

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[183] Gordon, H.W., and Lee, P., A relationship between gonadotropins and visuospatial function, **Neuropsychologia**, 24, 563-576, 1986.

[184] Dorner, G., Rhode, W., Stahl, F., Krell, L., and Masius, W.G., A Neuroendocrine Predisposition for Homosexuality in Man, **Archives of Sexual Behaviour**, 4, pp.1-8, 1975 and Dorner, G., Neuroendocrine Response to Estrogen and Brain Differentiation in Heterosexuals, Homosexuals, and Transsexuals, **Archives of Sexual Behaviour**, Vol. 17, No. 1, pp. 57-75, 1988.

[185] MacCulloch, M.J., and Waddington, J.L., Neuroendocrine Mechanisms and the Aetiology of Male and Female Homosexuality, **British Journal of Psychiatry**, 139, pp. 341-345, 1981.

in homosexuals,[186] but also the increased risk of AIDS; a ***Sunday Times*** year-end magazine for 1987 ran a photo-call of AIDS deaths in the well-known for that year, a very large proportion being in the visual and performing arts. More recently, ***The Independent on Sunday*** (1st December, 1991) repeated the exercise, bringing even more to attention the full extent of the toll taken by AIDS in the performing and artistic fields: Rock Hudson [actor], Geoffrey Ashton [theatre and art historian], David Robilliard [artist and poet], David Reichenberg [musician], Michel Foucault [philosopher], Robert Mapplethorpe [photographer], Bruce Chatwin [writer], Michael Sundin [actor], Willi Smith [fashion designer], Klaus Nomi [singer], Philip Core [artist and writer], Liberace [singer/pianist], Ian Charlson [actor], Halston [fashion designer], Douglas Lambert [actor], Keith Haring [artist], Perry Ellis [fashion designer], Brad Davis [actor], Michael Batchelor [dancer], Norman Eales (photographer), Freddy Mercury [singer]; since then others have been reported: Anthony Perkins (actor), Denholm Elliott (actor), Tommy Nutter (tailor and designer), Rudolf Nureyev (ballet dancer), Andrew Heard [artist], and literally hundreds more of the famous and successful in the arts. Were they contemporary artists, Botticelli, Leonardo, Michelangelo and Donatello, amongst many homosexuals or bi-sexuals in the History of Art, would be high AIDS-risks. To be homosexual does *not* indicate that the particular individual has a low level of sex hormones; rather, the sexual promiscuity of male homosexuals points towards the reverse conclusion.

A question which immediately comes to mind is "Why is there not an equivalent and equally lengthy list of scientists [mathematicians, physicists, chemists, biologists, geologists, engineers, and so on] who have died from AIDS-related diseases"? Obituaries may be selective in choosing to highlight artists rather than scientists; however, there appear to be to this writer an equal number of scientists eulogised in obituaries, none of whom have been reported as suffering from AIDS, although some male doctors and nurses are reported to have contracted it. Is there a conspiracy of silence in the scientific community which is more effective than some similar one in the artistic community? Perhaps the answer lies elsewhere: Simonton has related that scientists typically marry later, have fewer children, and divorce more often than most-is this an indication of a lower sex-drive, a consequent lack of promiscuity, either heterosexual or homosexual, and therefore a lowered risk of contracting the HIV virus and eventually AIDS? A class of students was asked "Which is sexier, an artist or a scientist"? The unanimous verdict was the artist!

Further to the remark above concerning homosexual men and their levels of serum testosterone, rather it seems that, according to Professor James Dabbs of Georgia State University (1990), it is *successful* individuals, with testosterone/adrenaline inspired motivation, drive and aggression, who are prominent in their fields, such as actors, football players, entertainers and women lawyers, who may be homosexual as well. Men of low status with high levels of testosterone are more likely to commit crimes,

186 Lindesay, J., Laterality Shift in Homosexual Men, **Neuropsychologia**, pp.965-969, 25, 1987.

become drug addicts and have more than 10 sexual partners in a year; 'sensation-seeking' behaviour is common in high testosterone men with little education and low income jobs. There is a feedback effect, however, where low self-esteem reduces testosterone level and high self-esteem increases it; it seems that both illegitimate and legitimate success produces increased levels of testosterone, the gang leader and the high-flying barrister pumping increasing levels of the very hormone likely to increase their success still further.[187]

Lansky, Feinstein, and Peterson found that, similarly to scientists in general, left-handers and left-mixed handers had a higher chance of not marrying, or, if married, had a higher chance of divorcing or separating than right-handers or right-mixed handers. Does this indicate something about the sexual problems of non-right-handers? Satz *et al* (1991) studied the hand preference of homosexual men (N=993) and its relationship to immune system functioning and performance on neuropsychological tasks, 491 of whom were diagnosed either HIV-positive or as having AIDS. Prevalence of left-handedness was between 13.1 and 14.5% in all sub-groups of the sample; there was no significant difference between right- and left-handers in incidence of immune system problems or allergies, thus not supporting either Lindesay (1987) or Geschwind and Galaburda (1985, 1987), or any of the other authors mentioned earlier who concluded similarly to the latter.[188] Satz *et al* supply the necessary dampening to any over-enthusiasm for the Geschwind and Galaburda thesis in its more extreme manifestations. It has to be made clear that, while inspirational, it still amounts to little more than a patchwork-quilt of experimental results and clinical judgements held together by a spider's web of exciting and suggestive correlations. Many of the conclusions drawn from it are certain to be wrong, and will be proven so in future; however, it is those, perhaps the greater number, which are going to be supported which make it an important theory.

Homosexuality is a sexual predilection which could become a factor to include in any retrospective study of artists. It is not an area of enquiry appropriate to the subject population of this study.

THE MATHEMATICIAN

There appear to have been a series of either idiot savant or highly intelligent "wonder calculators", such as Jedediah Buxton, Thomas Fuller, Zerah Colbourn, Louis Fleury, and Jacques Inaudi in the 19th century, down to Wim Klein and Arthur Benjamin in very recent years. Karl Friedrich Gauss was perhaps the most remarkable of the prodigious genuine mathematicians, closely followed by Ramanujan, John von Neumann, Norbert Weiner, and the sadly aborted genius, William James Sidis. The British prodigies, John Adams and Ruth Lawrence are

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[187] Ballantyne, A., Hormone opens door to success, **Sunday Times**, 22/7/1990.

[188] Satz, P., Miller, E.N., Seines, O., Van Gorp, W., D'Elia, L.F., and Visscher, B., Hand Preference in Homosexual Men, **Cortex**, 27, 25-306, 1991.

obvious contemporary examples.[189] It seems that common characteristic are detectable in most of these exceptional mathematicians, with, of course, the primary one that of precocity itself. Mitchell (1907), a mathematical prodigy who, like Bidder, wrote intelligently concerning his own nature, stated:

There is nothing more striking about the mathematical prodigies, nothing which has been the subject of more uncritical amazement, than their almost uniform precocity. Gauss began his calculations before he was 3 years old; the present writer, at 4; Ampere, between 3 and 5; Colburn, at 5; Safford, at 6 or earlier; Mathieu le Coq, Mr. Van R., of Utica, Bidder, Prolongeau, and Inaudi, at 6; Mondeux, at 7; the Countess of Mansfield's daughter, at 8 or earlier; Ferrol, Mangiamele, Grandmange, and Pierini, at early ages not definitely stated. Buxton's mental free beer record began from the age of 12; Zaneboni's calculation began at the same age; Dase attended school at the age of 2 and a half, and took to the stage at 15. In short, precocity is unmistakably the rule...[190]

Maths, Myopia, And Gout

Famous prodigies in maths from the early part of this century such as Sidis and Norbert Weiner have been well documented,[191][192] however in more recent years researchers such as Camilla Benbow at Johns Hopkins University, and Iowa State University, have been conducting wide and long-term trawling of the mathematically highly able pre-13 year olds as measured by the Scholastic Aptitude Test-Mathematics (SAT-M). Since 1980, she and her associates have tested some 50,000 children nation-wide, coming up with around 260 exceptionally talented young mathematicians. She and Robert M. Benbow established that allergies, immune disorders, left-handedness, and myopia were associated with extreme precocity in mathematics.[193][194] In addition, they found that mathematical reasoning

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[189] A report in The Times of 19/8/88 told of Ganesh Sittampalam, from Surbiton, Surrey, who, at 9.4 years passed two 'A' Level Mathematics papers at Grade "A". His maths teacher at Surbiton High School, Mrs Elisa Money, was quoted as saying: "Quite frankly, he's brilliant." He is superior to both John Adams {who could manage only one "C" Grade} and Ruth Lawrence {who was five months older when she gained her one "A" Grade in mathematics}. This is ability accelerated to such an extent that, viewed as a linear progression, Ganesh is operating solely in **mathematics** at the level expected of 18 year-olds, and perhaps only the top 10% of those. At 10 years he embarked on a mathematics degree course at Surrey University, gaining a first class degree in 1992 after just 60 days of part-time study. An only child, he used to study bus timetables in fascination with their numerical patterns; myopic, he seems from photographs to be somewhat ambidextrous, writing with both hands. He walked and talked late. { report in Daily Telegraph, 14/7/92.}

[190] Mitchell, F.D., Mathematical Prodigies, **American Journal of Psychology**, 18, 1907, pp.61-143.

[191] Montour, K.,William James Sidis, The Broken Twig, pp. 265-279, **American Psychologist**, April, 1977.

[192] Weiner, N., **Ex-Prodigy: My childhood and youth,** New York, Simon & Schuster, 1953.

[193] Benbow, C., and Benbow, R.M., Biological Correlates of High Mathematical Reasoning Ability in G.J. De Vries {ed}, **Progress in Brain Research**, Vol.61, Elsevier, Amsterdam, 1984.

[194] In 1976 Heim and Watts matched 203 left-handed writers for sex and total score on the AH2/3 test with the equivalent number of right-handed writers, comparing them for scores on verbal, numerical, and perceptual sub-scales; there were significantly more left-handers who scored higher than their paired right-handers on the numerical scale. The left-handers' superiority on the numerical test was clear and highly significant for males but not clear for females, who showed only a slight trend in this

ability appears to be related to spatial ability.[195] The marked disproportion of numbers of males to females in the top 3% of the precociously mathematically gifted discovered by the Benbows in their enormous survey (12.9 to 1) seem to indicate a further correlation with spatial ability, as males are firmly identified as being superior to females in tasks involving visuo-spatial skills.[196] Such skills have long been identified as a function of the more holistic right cerebral hemisphere,[197] and for an equally long time been identified as an essential component of artistic ability.[198]

A description of what it is to be mathematically gifted is shown below:

The mathematically gifted:

1) Perceive mathematical material in a problem analytically and synthetically. Generalise quickly and broadly both the content of a problem and the method of solution.
2) Curtail processes for solving similar problems with relatively little exposure to them.
3) Switch easily from one cognitive process to another.
4) Do not depend on conventional solution techniques.
5) Strive for elegant solutions.
6) Reverse reasoning processes easily.
7) Thoroughly investigate aspects of difficult problems before directly attempting to solve them.
8) Remember generalised and curtailed structures associated with problems and their solutions.
9) Tire both mentally and physically less readily during mathematical activity than during other kinds of lessons.
10) View the world mathematically.

TABLE ONE: COGNITIVE CHARACTERISTICS OF MATHEMATICALLY GIFTED STUDENTS[199]

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direction. Heim, A.W., and Watts, K.P., Handedness and cognitive bias, **Quarterly Journal of Experimental Psychology**, 28, pp.263-272, 1976.

195 Benbow, C.M.,*et al* , Physiological Correlates of Extreme Intellectual Precocity, pp.719-725, **Neuropsychologia**, Vol. 24, No. 5, 1986.

196 Maccoby, E., and Jacklin, C., **The Psychology of Sex Differences,** Stanford University Press, 1974, and Wiltig, M.A., and Peterson, A.L.{eds}, **Sex Related Differences in Cognitive Function**, Academic Press, 1979.

197 Bradshaw, J.L., and Nettleton, N.C., The nature of hemispheric specialization in man, pp.51-91, **Behavioural and Brain Sciences**, 4, 1981.

198 Kirk, Ursula, Hemispheric Contributions to the Development of Graphic Skill, pp.193-228, in Best, C.T., {ed}, **Hemispheric Function and Collaboration in the Child,** N.Y./London, Academic Press, 1985.

199 Benbow, C.

Durer, da Vinci, Brunelleschi (who, together with Alberti, was the inventor of single-point perspective), Piero della Francesca, and Sir Percival Wren were all artists, architects, and inventors with a pronounced interest in volume, space, and visual orientation, together with well-developed mathematical abilities. It appears that Durer, at least, had some problems with his eyes, according to Trevor-Roper in his ***The World Through Blunted Sight,***[200] having one "wandering" eye, the left. Other myopic artists were Monet (possibly), Cezanne, Renoir, Degas, Pissarro, Dufy, Derain, Braque, Vlaminck, Matisse, Kokoschka, Max Slevogt, Holman Hunt, and, Trevor-Roper speculates from pictorial evidence, so were Van Eyck, Frans Hals, Vermeer, and Van Gogh.

Trevor-Roper goes on to detail the "myopic personality", someone who is more punctual, attentive at school, has more academic hobbies, and less interest in sport than their normal-sighted fellows; they tend to stay up later than the normal-sighted, while mystics and religious leaders, as well as musicians and artists, are said to be frequently myopic, a blurred view of the outside world being no impediment to their inner vision. Bismarck, Schopenhauer, Goethe, Schiller, George Washington, Louis XVI, Napoleon, Keats, Shelley, Tennyson, Dr. Johnson, Milton, Yeats, Pope, Dante Gabriel Rossetti, Edward Lear, Wordsworth, James Joyce, Schubert, Wagner, Beethoven, J.S. Bach, and Gregor Mendel were all, apparently, myopic. Short sight and gout were inherited through the generations of the Medici family. Joyce wrote of himself:

> ...being as weak of sight as he was shy of mind, he drew less pleasure from the reflection of the glowing sensible world through the prism of a language many-coloured and richly storied than from the contemplation of an inner world of individual emotions mirrored perfectly in a lucid supple periodic prose...
> ***Portrait of the Artist as a Young Man*** [201]

The relationship between myopia and giftedness has long been of interest to psychologists and geneticists; Karlsson (1973) produced data from Iceland to give support to the previously documented association of near-sightedness and scholastic ability. Like Benbow, he found a particular link between myopia and mathematical inclination.[202]
80 ex-students of the Gymnasium who had graduated over a 30-year period with an overall grade point average of 90% or higher, 43 in the mathematics section and 37 in the humanities, were studied by Karlsson. He found that, compared with the 9% myopia level of the controls, 35% of the honours students were myopic, a reliably significant difference: almost half of the mathematics honours graduates were myopes; just two women had graduated with highest honours in that 30 year period: both were myopes. Gifted myopes, stated Karlsson, seem to arise from

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200 Trevor-Roper, P., **The World Through Blunted Sight,** London: Penguin Books, 1988.
201 cited in Trevor-Roper, p.35.

202 Karlsson, J.L., Genetic relationship between giftedness and myopia, **Hereditas**, pp.85-88, 73, 1973.

families with hereditary myopia. His results supported a recessive mode of inheritance with essentially complete penetrance in homozygotes.[203] The risk in adult sibs of index cases appears to be 25, 50, or 100 percent, depending on whether neither, one or both parents are affected. He speculates that brain stimulation may be the primary action of the myopia gene, with the development of short-sightedness in the homozygote being an unfortunate by-product, a situation somewhat similar to that found in African blacks with sickle cell anaemia, in whom the heterozygote has a selective advantage while the homozygote reduces the chances of survival. The worst effects of both anaemia and myopia have, however, largely been alleviated by modern medicine.

Dunphy (1970) mentions longitudinal studies which had earlier found a greater incidence of myopia among older academic populations in Japan, Austria, and Russia, going on to refer to a study carried out among Oxford undergraduates in whom myopia was found to be much more frequent than among National Service candidates.[204] He cites a study which indicated that myopic children grow faster and mature earlier than non-myopic children, particularly females. Female children with early menarche had axial lengths which increased more than those with late menarche, while a diet low on protein seemed to predict an increased likelihood of myopia. Near-work and "eye-strain" do not seem to be the root cause of myopia because illiterates and unlettered ethnic groups demonstrate myopia as well as bookish Europeans and Americans.

The posterior sclera is the last to develop in the foetus, and thus if myopia does occur, the posterior segment of the eyeball stretches the most under, perhaps, increased vitreous volume. Defective collagen development in the posterior sclera may allow the axial length to increase through allowing it to stretch more than is normal. Possibly the connection mentioned above with early onset of puberty may link myopia further with changes in hormone levels not only in the adolescent but in the foetal environment. Both glaucoma and retrolental fibroplasia seem related to myopia, with the added association for the latter condition that it is often found in autistic individuals, such as the musical savant, Leslie Lemke. Retrolental fibroplasia, which causes clouding of the vitreous and overgrowth of the retina, and can lead in extreme cases to the eye bursting in the socket, caused Lemke to have his eyes removed at six months old.[205] In 1975, Karlsson continued his researches in California, studying 17-18 year-old high school students, finding that IQ tests showed a consistent 8 point advantage to myopes over non-myopes, while comparison with

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203 **Ibid**, p.87.

204 Dunphy, E.B., The Biology of Myopia, **The New England Journal of Medicine,** pp.796-800, Vol.283, No.15, October 1970.

205 Treffert, D.A., An Unlikely Virtuoso: Leslie Lemke and the Story of the Savant Syndrome, **The Sciences,** January/February, pp.28-35, 1988.

tests carried out on the same subjects 10 years earlier showed that the higher IQ levels were present before the development of near-sightedness [**TABLE TWO**].[206]

IQ RANGE	N	% MYOPIA
55-74	30	0.0
75-94	516	7.4
95-114	1317	12.5
115-134	619	24.9
135-	45	44.4

Chi-Square based on an even distribution 114.5, $p<0.001$

TABLE TWO: FREQUENCY OF MYOPIA IN RELATION TO IQ SCORES 17-18 yrs. [high school students in Napa, California] (adapted from Karlsson, 1975).

Sofaer and Emery (1981) distributed a postal questionnaire to British members of Mensa (minimum entry requirement: an IQ of 148 on the Cattell scale), finding a real association between high IQ and infantile autism, gout, and myopia.[207] They, too, speculated that the genes responsible for these diseases might be causal for cerebral development and function, a pleiotropy. The incidence of autism in sibs and children of Mensa members who replied to the questionnaire was 3.2 to 6.3 times greater than that reported for the general population, while the incidence of myopia (not compared with population norms for lack of what the authors considered an appropriate criteria) before the age of ten years was 19.9% of the respondents (N=1355), 10.9% of the sibs, 11.5% of the children, and 5.2% of the parents.[208] The incidence of gout was twice that at age 44 reported for the general population among sibs of both sexes (age 35). There was a significantly greater prevalence of gout among male respondents than among brothers of all respondents. Gout is a genetically passed-on disorder involving the breakdown of the metabolic chain that serves to keep the levels of serum uric acid low. High levels cause the deposit of uric acid crystals on toe and hand joints, with consequent great pain and swelling. Among mammals, significant levels of serum uric acid are found only in the higher apes and in humans, other mammals possessing the enzyme uricase which oxidises uric acid to allantoin. Uric acid has been suggested to

206 Karlsson, J.L., Influence of the Myopia gene on brain development, **Clinical Genetics**, pp.314-318, 8, 1975.

207 Sofaer, J.A., and Emery, A.E., Genes for super-intelligence? **Journal of Medical Genetics,** pp.410-413, 18, 1981.

208 p.411, **Ibid**.

be a brain stimulant, like other purines, acting on the cerebral cortex. Uricase, the enzyme which breaks down uric acid in humans, may have been rendered weak by mutations which to some extent caused evolutionarily advantageous superior intellectual powers to have arisen in the primates. Glutamic acid, which is involved in the production of endogenous uric acid, appears to improve cognitive function when given therapeutically to retardates. Uric acid may be the missing brain stimulant element in Karlsson's speculation concerning the advantageous aspect of myopia. Research to further confirm this must necessarily involve proving a link or association between myopia and gout separately from any association with high IQ or academic success.

While all of the above seems very convincing, other writers have not agreed that myopia and high intellect/talent go together. Ashton (1983) tested a population of Hawaiian families for refraction in relation to cognitive test scores, finding that while there was a significant negative correlation between refraction and a verbal factor and first principal-component scores-although not with spatial, speed, or memory factor scores-after adjustment for age, birth order, years of education, and sibship size, the proportion of variation in refraction accounted for by cognitive test score differences was a mere 1-3%. He concluded that refraction status in general and myopia in particular are not strongly associated with cognitive ability and that it is unlikely that they share significant common developmental determinants.[209]

Something that occurs to the reader immediately is the particularity of the sample population: one is expected to believe that it is possible to generalise to all humans from a sample of Hawaiians, a dubious assumption. Ashton appears to have done his best by a considerable number of adjustments to the originally strongly significant negative correlation to reduce it away, while not quite succeeding in doing so. It may be that students in higher education in Reykjavik are a different population, genetically, to Californian students, who in turn are that much different from members of Hawaiian families. In addition, the correlation between myopia and high IQ/high academic achievement was the most striking in the earlier studies, falling away in strength of relationship as the normal population was approached. It appears that a relationship between myopia and IQ/talent may be predictable only in the most able of human beings.

[209] Ashton, G.C., Myopia and Cognitive Ability, **Behaviour Genetics**, Vol.13, p.526, 1983.

The Inarticulate Spatial Genius

Those individuals with a deficiency in what appears to be the more sequential, analytic left hemisphere, a lack of verbal or written word ability, may be at a disadvantage in an educational system geared toward such left hemisphere functions, while the skills of those who have a predominantly right-side cognitive profile may not be fully exploited.[210] It may be, however, that right-side skills *are* being used, but not in an obvious fashion. Annett, the author of the "Right-Shift" theory of genetic inheritance of sinistrality, states that excessive bias to the left hemisphere is associated with motor slowness of the left hand, and possibly the right hand as well in males, and that it is detrimental to mathematical thinking. She found that mathematics students and teachers were less likely to be right-handed, although this held true only for the males. In addition, Annett points out that, as left-handedness has not been found by the forces of natural selection to be counter-survival and thus bred out of human beings, it must confer *some* advantage.[211] Perhaps those skills which depend on spatial ability have been found evolutionarily useful and so remain part of our genetic heritage to the present day. It is ironic that a skill such as mathematics, which is so inextricably interwoven with modern science and technology, may depend to some extent on a neural capacity which once assisted Palaeolithic hunters to hit their targets with flint-tipped spears.

Einstein struggled constantly to express himself, and, because of this disability, was thought in his childhood to be mentally retarded.[212] Many other mathematicians have been similarly lacking in verbal fluency; indeed, in the **Mathematical Lectures of Isaac Barrow** (London, 1734) it was said that to say a person is an accomplished mathematician implies that he will be "... a most wretched orator...", and an eloquent mathematician has been called "...as rare a phenomenon as a talking fish...".[213]

Both calendar calculation and *computational* mathematics, as opposed to *relational* mathematics, may not require high spatial ability. It seems significant in this context that females are as able, if not more able, than males at all levels of computational mathematics until the highest peaks of theoretical and relational mathematics are reached, when they tend to fall away. Only a very few are found in this area. Probably it is here that the male superiority in spatial ability begins to make itself

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210 Fletcher, Hazel M., The Corpus Callosum...Contributions to Culture, unpublished Bsc dissertation, University of Edinburgh, 1986.

211 pp.354-355, Annett, M., **Left, Right, Hand and Brain: The Right Shift Theory**, Lawrence Erlbaum, London, 1985.

212 Frank, P., **Einstein, His Life and Times**, London, Johnathan Cape, 1948.

213 p.316, Appendix 2, Macfarlane Smith, I., **Spatial Ability: Its Educational and Social Significance,** University of London Press Ltd., 1964.

felt.[214] The above seems to be supported by the work of Elizabeth Fraser, a research assistant at Edinburgh University's Mathematics Department, who has published a paper called The Gender Factor in Mathematics,[215] which states that Scottish schoolgirls are more likely to achieve mathematics entrance qualifications than, presumably, their counterparts in other areas of Britain. It is a difference which has been identified as arising from the Scottish Highers system, which is more broad-based than "A" Levels. Fraser makes the claim that in Scotland everyone is encouraged to do maths if they are at all capable of it, a rather dubious contention, implying as it does that elsewhere individuals who are capable of achieving mathematical skills are *not* encouraged.[216] At a secondary school, male pupils drifted into maths because it is a high prestige subject and confirmed their academic capability, while female pupils showed a keener interest in the discipline, having a much more positive view of maths as a subject. However, once at University, female students developed a more negative view of the course than men, saying they found it both less useful and more difficult. Could it be that the more theoretical and abstract nature of mathematics as it is taught at University, where it is less computational and more relational in nature than in secondary education, acts to discourage female maths students, who would tend to be less able in any intellectual process involving spatial manipulation? Elizabeth Fraser records that Edinburgh has a particularly high proportion, 50%, of female mathematics undergraduates; it is a cause for concern that, therefore, half of Edinburgh's maths students may be dissatisfied with their subject and their course.[217] Obviously, there must be some who are happy with their course,[218] nevertheless, considering the shortage of mathematicians at present, everything possible ought to be done to ensure none are discouraged in their choice of a career. It is therefore desirable that

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214 It would be interesting to be able to examine an NMR brain-scan image of Ruth Lawrence, the mathematics prodigy, in order to measure her corpus callosum; it is unlikely, however, that permission would be given. Her handedness, or that of Ganesh and Adams is not clearly apparent. It would be supportive to the theory being followed here if, like Benjamin Franklin, they were left-handed.

215 reported in the Times Higher Education Supplement, w/e 23/7/88.

216 With present curricula, it is more likely that age-typical strong ability in maths is easily detected across all of Britain, and, unlike "uncanny" precocious ability, is immediately commended and encouraged in most pupils. Precocious ability always disconcerts teachers, who are not trained to deal with children manifestly operating at ability levels beyond the expected age-locked curriculum level, and who often prefer to give such children "busy-work" to keep them quiet. In addition, such pupils are not welcomed by teachers who do not wish to be seen by the rest of the class spending more time and apparently giving more care and attention to a favoured and exceptionally talented child. They are usually seen as being "able to take care of themselves."

217 As a supporting piece of anecdotal evidence, a female mathematics graduate has said that she found herself being out-distanced by her male peers in precisely those areas of maths that required manipulation of the relationships between highly abstract concepts; she found that her preference was for more concrete maths options, where, as she put it, she could "keep my feet on the ground!"

218 It would be interesting to see how many of those who declare themselves happy with the way in which the subject is taught are left-handers.

mathematics tutors be made fully aware of the special problems and differing skills they are likely to encounter in their female students.

The greater number of Edinburgh University mathematics students being female, and the greater number of Scottish schoolgirls taking mathematics as a subject and doing well, as found by Fraser, may be phenomena which are capable of explanation in a different way to that taken by Fraser. The greater proportion of both schoolgirls and students are of Scottish derivation, arguing for a shared genetic inheritance and a shared set of gestatory influences. Rather than taking a strictly environmentalist point of view, as Fraser has done, it may, therefore, be possible to seek for inherited and developmental causes to explain the differences found by her in Scottish female maths students. As Eysenck stated in the Peer Commentary on Benbow,[219] the consequences of a 100% genetic determination would be identical with those of a 100% environmental determination-all of the alleged environmental factors would then appear as a simple consequence of genetic and developmental differences.[220] In practice, of course, neither set of factors is wholly responsible for the observed differences.

A three-year study by Fennema and Tartre in the use of spatial visualisation in mathematics by girls and boys showed that students who differed in spatial visualisation skill did not differ in their ability to find correct mathematical problem solutions, although those who possessed a high level of spatial skill tended to use that in problem-solving by preference. Low spatial visualisation was thought to be more debilitating to girls' mathematical problem solving than to boys'. Fennema and Tartre quote Schonberger (1976) when they say that scores on tests of spatial visualisation and mathematics achievement correlate in the range of .3 to .6, and that spatial visualisation appears to account for some of the variance in ability to solve mathematical problems.[221] Fennema and Tartre go on to write that the contribution of *verbal* skills to mathematics performance is well documented; as females are known to excel in verbal skills, it seems strange that they do not excel at mathematics as well. Their reading of the literature had suggested that the balance between verbal and spatial skills must be considered, as many mathematical problems can be solved both verbally and spatially. Equal skill in both areas would enable the student of maths to have "two strings to his/her bow", ensuring greater success than a student skilled only in one of the two areas. The students chosen for this longitudinal study were discrepant in spatial and verbal skills, the reasoning behind this being that those who were highly spatially skilled and poor in the verbal area would be more apt to use their best skill in maths problem solving than

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[219] Benbow, C., Sex differences in mathematical reasoning ability in intellectually talented pre-adolescents: their nature, effects, and possible causes, **Behavioural and Brain Sciences**, 11 (2), 1988.
[220] Eysenck, H.J., O Tempora, O Mores! **Behavioral and Brain Sciences**, 11 (2), p.189, Peer Commentary on Benbow, C.P., Sex differences in mathematical reasoning ability... 1988.
[221] Schonberger, A.K., The interrelationship of sex, visual spatial abilities, and mathematical problem solving in grade seven, Doctoral Dissertation, University of Wisconsin-Madison, 1976.

students with the reverse capabilities, while the latter would be more apt to use verbal skills in the same situation.

Their results went some way toward confirming Lean and Clements' (1981) conclusions that students who process mathematical information by verbal-logical means outperform students who process mathematical information visually.[222] While not completely agreeing with Lean and Clements, Fennema and Tartre say that one should question the idea that spatial visualisation skills are highly important in the learning of mathematics and that the development of such skills should become a major goal of mathematics education-their study of 6 to 8th grade children caused them to be sure that high spatial skill did not give any sort of an edge.[223] It is unfortunate that the study did not use a subject population of mathematics high achievers, but rather drew from a normal population; strategies and skills used by high maths achievers may well have proved different.

Marshall (1983) went some way to confirming the conclusions of Fennema and Tartre when finding that girls were more likely than boys to make errors by *misusing* spatial information, using irrelevant rules, negative transfer, inappropriate key word associations, or the choice of incorrect operations. Boys, Marshall found, were more likely than girls to make errors of perseverance and formula interference.[224] The subjects used by Marshall were drawn from elementary schools and the instrument used was the mathematics section of the Survey of Basic Skills (USA). There are no tests for relational mathematics skills for children younger than 12 years, as opposed to tests of computation and basic arithmetical facts.

Becker (1978) found that spatial ability was related to superior performance on the SAT-M as a whole, although the SAT-M, in fact, possesses few items with a spatial component. Becker used a spatial test for her high math ability subjects which had a large verbal component, however; it may be that her finding of no differences on the SAT-M due to sex or spatial ability was confounded by the seventh grade girls tested using a verbal strategy to solve the items in the spatial ability test.[225]

Hier and Crowley (1982) decided to go directly to the root of male hormonal production, looking at the possible association between testicular size and spatial

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[222] Lean, G.A., and Clements, M.A., Spatial ability, visual imagery, and mathematical performance, Report No.10, Lae: Papua New Guinea University of Technology, Mathematics Education Centre, 1981.
[223] Fennema, E., and Tartre, L.A., The use of spatial visualization in mathematics by girls and boys, **Journal for Research in Mathematics Education,** Vol.16, No.3, pp.184-206, 1985.
[224] Marshall, S.P., Sex differences in mathematical errors: an analysis of distractor choices, **Journal for Research in Mathematics Education**, 14, pp.325-336, 1983.
[225] Becker, B.J., The relationship of spatial ability to sex differences in the performance of mathematically precocious youths on the mathematical sections of the Scholastic Aptitude Test, Master's Thesis, The Johns Hopkins University, 1978.

ability: they found that when they measured the testicular volume of 19 men with idiopathic hypogonadotropic hypogonadism [IHH] (using a Prader orchidometer) that larger testicular size correlated positively ($p<.05$) with better performance on the Wechsler Block Design and Embedded Figures sub-tests, and *not* with scores on the verbal tests.[226] It is not suggested that generalisations can be easily made from IHH individuals to normals, nor that enormously enlarged testicles are a prerequisite for great mathematical ability-if that were the case those histologists studying Einstein's brain to find the source of his genius are looking at entirely the wrong part of his anatomy-nevertheless, there may be sex differences in both spatial and mathematical ability deriving from differences in hormone balances.

It seems likely that, in cognitive tests, females will be less able in maths and show a more balanced hemispheric profile than males, while those most able in both mathematics and right hemisphere functions will be male.

Art And Science, And The Left-handed Female Student

When Peterson studied differences between student artists and scientists,[227] he found an elevated incidence of left-handers in those majoring in music and the visual arts compared with those in the sciences, 14.89% and 12.24% respectively, as compared with 4.35%. Judged by the above, the standard first year undergraduate essay question "Is Psychology an Art or a Science?" remains an unresolved conundrum, certainly not being answered by Peterson's finding that the Behavioural Sciences fall neatly in the middle of this range, at 8.89%! It may be that the only true deciding factor as to which is an Arts and which a Science discipline is in the degree to which the particular discipline foregrounds or requires mathematics. However, as there were 9.13% left-handed females as opposed to the average of 5.9% found in other such studies, it seems that First Year Psychology draws a larger proportion of left-handed females than might be expected. If females in general are more often right-handed than males, therefore with a greater chance of being left hemisphere dominant (although with better communication between hemispheres than the male, and with an associated greater bilateralisation of function) then it seems reasonable to assume that a left-handed female, with a greater likelihood of having some right hemisphere dominance than right-handed females, will prove more capable in visual-spatial tests, and probably for that reason prove to be talented in both art and mathematics as well. Given a corpus callosum of the usual female inter-hemispheric communicative efficiency, she should certainly have far greater fluency in *describing* her work than the males in those disciplines. Her essay marks should average out at a higher grade than that of her

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226 Hier, D.B., and Crowley, W.F., Spatial Ability in Androgen-Deficient Men, **The New England Journal of Medicine,** Vol. 306, No. 20, 1982.
227 Peterson, J.M., Left-handedness: differences between student artists and scientists, pp.961-962, **Perceptual and Motor Skills,** 48, 1979.

male peers.[228] Gordon and Lee found that right-handed women were poorer than right-handed men on visuospatial tests, and better on verbal fluency.[229] A discipline which may be called part-art and part-science such as Psychology might seem doubly attractive to left-handed females with bilateralisation of hemispheric function and perhaps a right Cognitive Profile. Art, Maths, and Architecture, too, from this reasoning, might attract more than their fair share of left-handed females. Unfortunately, Peterson did not analyse his results along this particular dimension. There may be a higher number of female left-handers in such disciplines than in others.

Acalculia

Francois Boller and Jordan Grafman[230] have described acquired calculation disturbance (Acalculia), quoting Hecaen with regard to the differing varieties of the disorder. There appear to be three main types:

1) **Alexia** and **agraphia** for digits and numbers, with or without alexia and agraphia for words and letters-arithmetic operations are affected by impaired ability to read and write; this is associated in most cases with lesions of the left temporoparietal area, and was found in 34% of Hecaen's subjects.

2) **Spatial acalculia**, a disorder of spatial organisation where the rules for setting written digits in their proper order and position are not followed; spatial neglect and number inversions may be found, as well; this was associated with lesions of the right parietal lobe and adjacent areas, and was found in 26% of Hecaen's subjects.

3) **Anarithmetia**, a disorder of the "conduct" of arithmetic operations, where alcalculia is not clearly related to either disorder listed above. This was found in 40% of Hecaen's subjects, and seemed to involve damage to both or either cerebral hemispheres generally. Hecaen concluded that calculation requires a high level of integrated work by both hemispheres.

The authors state that even though different factors may contribute to calculation disorders (impairment of intelligence, visuo-constructive difficulties, aphasia), left posterior lesions are particularly instrumental in producing impairment of calculating abilities, an impairment partially independent of the above disorders.[231]

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[228] Netley, C., and Rovet, J., **Relationships among brain organization, maturation rate, and the development of verbal and nonverbal ability, in Language Functions and Brain Organization,** Segatowitz, S.J., N.Y., Academic Press, 1983.
[229] Gordon, H.W., and Lee, P.A., A Relationship Between Gonadotropins and Visuospatial Function, pp.563-576, **Neuropsychologia**, Vol. 24, No. 4, 1986.
[230] pp.473-481, Chapter 31, **Handbook of Clinical Neurology**, Vol.1, {45}, Fredericks, J.A.M., editor, Elsevier, 1985.
[231] p.479, **Ibid.**

It appears that calculating ability can be disturbed by:
1) inability to appreciate the meanings and names of numbers;

2) visuo-spatial impairment that interferes with the spatial arrangement of numbers as well as with the mechanical aspects of operations;

3) inability to remember and/or retrieve mathematical facts and to use them in proper sequence;

4) inability to engage in mathematical thinking and to understand the concepts underlying mathematical operations. If a specific brain area is suspected of being implicated in acalculia, it may be the left angular gyrus.[232] 1) would imply a left hemisphere verbal skill, 2) would suggest the involvement of right hemisphere spatial abilities, 3) might involve the use of left hemisphere temporal lobe and hypothalamus capacities and functions, while 4) points towards the use of associative regions in both hemispheres.

As Camilla Benbow has found,[233] there are many types of mathematical ability; she goes on to make a distinction between what tests measure, higher-level abilities, and the low-level skills which school grades measure. Grades often depend on how often homework is handed in, or how neat it is, or how quiet and attentive the student is. She says:

> ..the curriculum emphasises computation and the learning of basic concepts and few tests have been designed to measure any other abilities in that age group. I am not aware of any tests of mathematical *reasoning* ability designed for elementary students.[234]

The present writer would prefer to re-name the latter ability *relational* , due to the belief that it includes a greater proportion of spatial manipulation than does computational maths. Burnett, in the peer commentary on Benbow's article,[235] points out that those researchers who have used some index of mathematical achievement (grades), or have looked at problem-solving accuracy rather than speed or aptitude, or have used students of only average ability as subjects, or who have used inadequate measures of spatial ability have been the ones who have denied the connection between mathematical and spatial ability. Spatial visualisation tests such as the Guilford-Zimmerman, or those which require speed, complex working, and a

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232 p.480.
233 pp.169-232, Benbow, C., Sex differences in mathematical reasoning ability in intellectually talented preadolescents: their nature, effects, and possible causes, **Behavioral and Brain Sciences**, 11:2,1988.
234 p.218, **Ibid.**

235 pp. 187-188, Spatial visualization and mathematical reasoning abilities, Sarah A. Burnett, Peer Commentary, **Ibid.**

mental rotation, are the ones which more firmly link the two (as found in the many investigations into sex differences in mathematical skill). She says:

> ...reliable correlations between the mathematical and spatial constructs are more often found with higher ability high school and college students...Our data indicate that students gifted in spatial ability successfully use spatial strategies to solve mathematical problems; however, other strategies are also appropriate, and some students not high in spatial visualisation use these effectively to solve mathematical problems...[236]

Sanders, another commentator,[237] quotes Annett and Kilshaw:[238]

> Mathematics is a discipline for representing those aspects of the world which would otherwise be represented as complex spatial images. It would be fruitless to argue whether mathematics is a verbal *or* spatial activity when it is the discipline which co-ordinates and unifies these two aspects of human intellectual activity.[239]

Sanders feels that Benbow's speculation that sex-differences in mathematical ability at the highest level are produced solely by the sex-difference in spatial ability is admissible, while to postulate some separate mathematical "intelligence" based in the right hemisphere is not-there is simply no evidence to support the latter position. Burnett states that high-level students possess greater spatial ability than lower-level students.

Nyborg, yet another commentator,[240] derives a somatic prediction from his own Androgen-Oestrogen model concerning mathematically eminent people which chimes remarkably well with MacFarlane-Smith's somatic portrait study of the high spatial/mathematical individual (1964): the male mathematician will be either tall and slender or pyknic, will have low muscle content and accordingly show decreased muscular strength, will be long-lived, and will have been a "sissy" as a child (!).[241] The female mathematician will be tall, slender, and strong, and will have had a childhood history of tomboyism. Mathematically eminent people go into puberty late, says Nyborg, and show a prolonged period of brain development. They are typically first-born, come from a family with few children, and have, themselves, few offspring (in particular, few dizygotic twins). They show reduced physical aggressiveness, high behavioural restraint, introversion, and prefer

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236 p.187, **Ibid.**

237 pp.208-209, Mathematical ability, spatial ability, and remedial training, Barbara Sanders, Peer Commentary, **Ibid.**

238 Annett, M., and Kilshaw, D., Mathematical ability and lateral asymmetry, **Cortex**, 18:547-568, 1982.

239 p.564, **Ibid.**

240 pp.206-207, Mathematics, sex hormones, and brain function, Helmuth Nyborg, Peer Commentary, Benbow: Sex Differences in Mathematics, 1988.

241 p.207, **Ibid.**

abstractions and objects to people. They prefer controlled political development and appreciate a formal to a loose social organisation of society. Of course, he declares, the finding of many mathematically eminent, unrestrained he-men and opulent, very fertile, extroverted female mathematicians would serve to falsify such a model!

THE DYSLEXIC

Dyslexia And The Right Hemisphere

The Cognitive Laterality Battery of Harold W. Gordon was designed to test specialised cognitive function and provide profiles of relative performance in the individual between what have been identified as typically left hemisphere verbal and sequential skills and the spatial skills usually assigned to the right hemisphere.[242] Harness, Epstein, and Gordon,[243] using this battery, found that dyslexic children consistently performed above average on spatial tests, while their left hemisphere performance was 0.5 standard deviations below average, and concluded that the learning disabled tend to possess a right Cognitive profile.[244] Deutsch *et al* (1988) found that, using regional cerebral blood flow as a measure of work done in right hemisphere tasks, the rotation of a visualised object made the greatest demand on the striate cortex/occipital areas, and in particular the parietal area, conventionally identified as the site of visual-spatial functions. The female brain seems to use more energy in all its activities than the male, and these right hemisphere tasks were no different: the female subjects seemed to demand greater blood flow in the visual-spatial areas to complete the experimental tasks than did the males-perhaps they simply made more effort. There was right frontal activation observed, as well, which seems to indicate attentional demands.[245] Osaka found similarly, using the EEG to record right hemisphere activation during a rotation task.[246] Both studies tend to support the inclusion by Gordon of such a task in his Cognitive Laterality Battery.

Dyslexia, difficulty with both or either reading and speaking, has been speculated as being symptomatic of right-hemisphere control of those skills, where the normally dominant left-hemisphere for some reason has not taken up or has been prevented by brain damage from taking up its customary lexic and linguistic control. Max

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242 Gordon, H.W., The Cognitive Laterality Battery: Tests of Specialized Cognitive Function, **International Journal of Neuroscience**, 1985.

243 Harness, B.Z., Epstein, R., and Gordon, H.W., Cognitive Profile of Children Referred to a Clinic for Learning Disabilities, pp.346-352, **Journal of Learning Disabilities**, 17(6), 1984.

244 Gordon, H.W., The Learning Disabled Are Cognitively Right, **Topics in Learning and Learning Disabilities**, 3, (1), 1983.

245 Deutsch, G., Bourbon, W.T., Papanicolaou, and Eisenberg, H.M., Visuospatial Tasks Compared via activation of Regional Cerebral Blood Flow, pp.445-452, **Neuropsychologia**, Vol.26, No.3, 1988.

246 Osaka,M., Peak alpha frequency of EEG during a mental task: task difficulty and hemispheric differences, pp.101-105, **Psychophysiology**, 21, 1984.

Coltheart has put forward the "right-hemisphere hypothesis" for what is sometimes called "Deep Dyslexia". This is distinguished from "surface dyslexia" by the nature of the errors made by the dyslexic: deep dyslexics when attempting to read single words make errors determined partly by the semantic and syntactic nature of the target word and the semantic and syntactic processing of it, while the surface dyslexic makes errors governed largely by the spelling-to-sound characteristics of the target word.[247] Coltheart maintains that the deep dyslexic not only makes semantic errors, he/she makes visual, derivational, low-imagery word, and function word errors. In addition, the dyslexic will lack the ability to derive phonology from print. If it is postulated that the right-hemisphere has taken over reading in dyslexics, there are those who would deny that this is possible: Coltheart quotes Benson and Geschwind (1969)[248] that the right hemisphere is both "...word-blind and word-deaf...".[249] Studies carried out by them indicate that patients suffering from alexia without agraphia cannot read aloud, nor match written words with pictures or objects, and fail to carry out written commands with either hand.[250] Benson and Geschwind go on to assert that:

> ...it can be stated with some confidence that the ability to comprehend written language is dependent upon intactness of the dominant (usually left) hemisphere in the majority of adults.[251]

Neurophysiological studies have indicated that dyslexia is brought about by isolation of the left angular gyrus from the left and right occipital cortex, this isolation having been caused by the joint presence of two lesions: one which affects the left occipital cortex and produces right hemianopia, preventing the left angular gyrus from receiving input from the right visual hemifield, and the other which affects the splenium of the corpus callosum, the pathway from the right occipital cortex to the left angular gyrus. Such a splenial lesion would prevent the left angular gyrus from receiving input from the left visual hemifield. Thus, the left angular gyrus would be isolated from the entire visual field. Smith (1966)[252] is used by Coltheart with regard to left hemispherectomy cases, where the assumption that language is present only in the left hemisphere may be put to the test. Immediately after the removal of the left hemisphere of a 47 year-old patient, he was speaking, reading, writing and understanding language, although greatly impaired in all these areas. Six months after the operation, he was substantially improved in linguistic

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247 Definition from Marcell, T., Surface dyslexia and beginning reading: a revised hypothesis of the pronunciation of print and its impairments, pp.227-258, in Coltheart, M., Patterson, K., and Marshall, J.C., **Deep Dyslexia**, 2nd. edition, Routledge and Kegan Paul, London and NY, 1987.

248 Benson, D.F., and Geschwind, N., The alexias, in P.J. Vinken and G.W. Bruyn {eds.}, **Handbook of Clinical Neurology**, vol. 4, Amsterdam, 1969.

249 Coltheart, M., Deep dyslexia: a right-hemisphere hypothesis, pp.326-380, **Deep Dyslexia**.

250 p.329, **Ibid.**

251 **Ibid.**

252 Smith, A., Speech and other functions after left{dominant} hemispherectomy, **Journal of Neurology, Neurosurgery and Psychiatry**, 29, pp.467-471, 1966.

understanding. Zangwill examined the same patient (1967)[253] and found that he was sometimes able to read words, although not sentences, could print his name and copy script or designs, but he could not write the names of objects spontaneously or to dictation. The man exhibited a considerable amount of "automatic" or "emotional" speech, even some propositional speech. On the Peabody Picture Vocabulary Test, which measures comprehension of single spoken words, the patient scored 85/112, a substantial degree of speech comprehension, says Coltheart. He goes on to mention the two subjects, L.B. and A.A., who were examined and tested by Levy, Nebes and Sperry (1971),[254] Zaidel (1973),[255] Gazzaniga and Sperry (1967)[256] and Gazzaniga and Hillyard (1971).[257] These subjects had been commissurotomised, and yet evidence was found in them of some right hemisphere capacity to comprehend print, to spell, and to write. However, as Levy and Trevarthen (1977, p.106)[258] note, both appear to have received their critical brain injury at birth; abnormal language lateralisation from an early age cannot therefore be ruled out in these two subjects. Right hemisphere *inabilities* in split-brain patients, together with linguistic characteristics of recovering left-hemisphere damaged aphasics, might provide support for Coltheart's hypothesis, and so he continues with a review of such evidence. Coltheart lists Neilsen's (1946)[259] finding that right hemisphere damage could exacerbate aphasics' symptoms, that the prospects for recovery from aphasia were worse when there were EEG abnormalities of the right hemisphere than when there were not (Tikofsky, Kooi and Thomas, 1960),[260] that, using intracarotid sodium amytal, speech of some aphasics could be found emanating from the right hemisphere (Kinsbourne, 1971)[261], that aphasic subjects in a dichotic listening test with speech stimuli showed a left-ear advantage (Pettit and Noll, 1972),[262] and that a tachistoscopic word recognition test with a

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253 Zangwill, O., Speech and the minor hemisphere, **Acta Neurologica Psychiatrica**, 67, pp.1013-1020, 1967.

254 Levy, J., Nebes, R.D., and Sperry, R.W., Expressive language in the surgically separated minor hemisphere, **Cortex,** 8, pp.49-58, 1971.

255 Zaidel, E., Linguistic competence and related functions in the right hemisphere of man following cerebral commissurotomy and hemispherectomy, Doctoral dissertation, California Institute of Technology, 1973.

256 Gazzaniga, M.S., and Sperry, R.W. Language after section of the cerebral commissures, **Brain**, 90, pp.131-148, 1967.

257 Gazzaniga, M.S., and Hillyard, S.A., Language and speech capacity of the right hemisphere, **Neuropsychologia**, 9, pp.273-280, 1971.

258 Levy, J., and Trevarthen, C., Perceptual, semantic and phonetic aspects of elementary language processes in split-brain patients, **Brain**, 100, pp.105-118, 1977.

259 Neilsen, J., **Agnosia, Apraxia, Aphasia: their Value in Cerebral Localization,** New York: Hoeber, 1946.

260 Tikofski, R.S., Kooi, K.A., and Thomas, M.H., Electrencephalographic findings and recovery from aphasia, **Neurology**, 10, pp.154-156, 1960.

261 Kinsbourne, M., The minor cerebral hemisphere as a source of aphasic speech, **Archives of Neurology,** 25, pp.302-306, 1971.

group of aphasics showed a left visual field advantage (Moore and Weidner, 1974).[263]
Chris Code[264] advances further Coltheart's hypothesis, following Hughlings Jackson's conception of propositional (left hemisphere) and appositional (right hemisphere) language (the same conception used in the present study).[265] He cites some examples of non-propositional language:

1) Serial-automatic speech (e.g., counting, days of the week, months of the year, recited arithmetic tables)

2) Singing, recitation of over familiar verses and rhymes

3) Swearing, expletives, coprolalic, and emotional utterances

4) Conventional social greetings (e.g., good morning, good night, thank you, excuse me, nice day)

5) Conversational fillers (e.g., you know, sort of)

6) Overused phrases, idioms, clichés, and stereotyped expressions

Such automatic, non-propositional utterances appear to be invariant, almost impossible to transform, and are structured and produced holistically.[266] A CT scan study[267] appears to suggest that recurrent utterances occur in patients who have both left cortical and basal ganglia damage, with the further conclusion that the smallest lesion required to cause a recurrent utterance is an anterior lesion including the basal ganglia. Tourette's syndrome and Parkinson's disease both seem to involve basal ganglia damage and recurrent utterances.

Code summarises many studies concerned with reiterative utterances in patients suffering from anterior temporal lobe epilepsy, who produce ictal speech automatisms, and who have abnormal EEG readings over the right hemisphere. He concludes that the available evidence from these sorts of study indicate that the right hemisphere is involved in the production of certain kinds of non-

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262 Pettit, J.M., and Noll, J.D., Cerebral dominance and the process of language recovery in aphasia, Presented at the American Speech and Hearing Association, San Francisco. In A. Searlman, A review of right hemisphere linguistic capabilities, **Psychologial Bulletin**, 84, pp.503-528, 1972.
263 Moore, W.H., and Weidner, W.E., Bilateral tachistoscopic word perception in aphasic and normal subjects, **Perceptual and Motor Skills**, 38, pp.1003-1011, 1974.

264 Code, C., **Language, Aphasia, and the Right Hemisphere**, John Wiley & Sons, UK, 1987.
265 Jackson, H., The duality of the brain, **Medical Press Circ.**, 1: 19, 41, 63, 1874.
266 p.60, **Ibid**.
267 Brunner, R.J., Kornhuber, H.H., Seemuller, E., Sugar, G., and Wallesch, C-W., Basal ganglia participation in language pathology, **Brain and Language**, 16, pp.281-299, 1982.

propositional speech.[268] However, he summarises, as well, the criticism which has been aimed at Coltheart: that most of the available data is equivocal, and that it lacks respectable levels of replication. He quotes Patterson and Besner,[269] who compared the written word and sentence comprehension of two deep dyslexic patients with results obtained from the testing of split-brain subjects N.G. and L.B. on reading subtests of the Boston and Western Aphasia Tests and the Peabody Picture Vocabulary Test; the comparison showed that the two dyslexics were far more able than the split-brain subjects in these areas. Either the right hemispheres of N.G. and L.B. had poorer language skills than the normal right hemisphere, or the reading performance of the dyslexics reflected more than right hemisphere production. Right hemisphere lexicons may differ in size, however, and in the non-commissurotomised the left hemisphere, even when damaged or only partly operational, may still be able to assist an over-loaded right hemisphere.[270] Code notes:

> ...that such features as semantic errors (semantic or verbal paraphrasia), observable in a range of aphasia types, difficulty with function words in agrammatism, and a tendency towards success with words which are concrete, high in frequency and imagery on naming tasks, are not only features of deep dyslexia. In addition, there is the finding...that emotionality is also a characteristic of aphasic language, and this may implicate the right hemisphere.[271]

Nevertheless, the right hemisphere's contribution to language ability in the dyslexic and the aphasic will not fully make up the loss in the left hemisphere, nor will it be of the same type. RH involvement will be related to the severity of language loss and the time since onset, together with the variety of loss incurred.[272]

Facial expression has often been identified as under predominantly right hemisphere control.[273]

Retardation of the development of the left hemisphere is associated with all the so-called "learning deficiencies"; they are called that because they are deficiencies in the areas by which this language- and literacy-oriented society judges its people. Visual-spatial/holistic ability is far less prized in our present day world. In an earlier, non-literate society, the artistic dyslexic would have had no inkling that he was in any

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268 pp.72-73, **Ibid.**

269 Patterson, K., and Besner, D., Is the right hemisphere literate? **Cognitive Neuropsychology**, 1, pp.315-341, 1984.

270 p.145, **Ibid.**

271 p.146, **Ibid.**

272 pp.147-148, **Ibid.**

273 Borod, J.C., Kent, J., Koff, E., Martin, C., and Alpert, M., Facial Asymmetry while posing Positive and Negative Emotions: Support for the Right Hemisphere Hypothesis, **Neuropsychologia**, Vol.26, pp.759-764, 1988, and Code, pp.101-104.

way an "inferior" citizen, rather, his right hemisphere abilities would have been praised, and justly. It may be expected to find a raised incidence of dyslexia in either artists or their relatives. The French sculptor, Rodin, the creator of ***The Kiss* ,*The Burghers of Calais*** , and ***The Age Of Bronze*** , was dyslexic (as well as myopic).[274]

The Clumsy

Someone who cannot hold a knife or fork properly, or holds a pencil oddly, or who does not seem sufficiently co-ordinated to be able to ride a bicycle, dance or perform floor gymnastics may not ordinarily be called "clumsy". Motor skills are obviously of great interest to this research; however, they may be divided between the gross and the fine varieties. Movements involving the body trunk may be seen to be asymmetric: coaches commonly point out that ice skaters find it easier to execute turns in one direction rather than the other, while athletes prefer tracks which are run counter-clockwise, with the left side facing inwards. It may be that superior athletes are better at acquiring truncal skills. Axial movements such as those involved in truncal actions may be dependent on motor programs in either hemisphere in individuals with anomalous dominance and so greater bilateralisation, whereas it would normally be the left hemisphere containing these programs, with the outflow from them distributed bilaterally, or so say Geschwind and Galaburda (1985, 1987).

Pyramidal or fine motor skills depend primarily on purely contralateral motor systems arising in the precentral gyrus; however, in the normal individual, it may be that the programs for the pyramidal skills, too, lie in the left hemisphere. In bilateralised individuals they might lie in either hemisphere. Many individuals use their right hands for the finer control task of writing on paper, but their left for the larger movements of shoulder and arm of writing on the blackboard or painting. Some might write and perhaps produce sculpture with the left hand, and paint with the right. One hand may be used preferentially for fine or pyramidal tasks while the other may be preferred for gross or axial tasks. This conception of differential motor learning may account for the discrepancy often noted between gross and fine motor abilities in children with learning disorders, and, indeed, between immaturity of gross or axial motor skills in the precocious artist and the exceptional maturity of their fine or pyramidal motor skills. If an anomalously dominant right hemisphere held the site for the latter, much would be explained in such *wunderkinder*. Left-handers have been observed by Annett and Kilshaw[275] to show, on average, smaller differences in performance between the two hands than right-handers, almost blending into ambidexterity. Such individuals should show a higher level of skill in

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[274] in Grunfeld, F.V., **Rodin: A biography**, London, Century Hutchinson, 1988.

[275] Annet, M., and Kilshaw, D., <u>Mathematical Ability and Lateral Asymmetry</u>, **Cortex,** 18, pp.547-568, 1982.

any bimanual tasks. The famous two-handed backhand of Bjorn Borg is a case in point, while sculptors would find ambidexterity extremely useful.

Returning to "clumsiness", or "Developmental Co-ordination Disorder", or even "dyspraxia": it is something with no known aetiology, but which occurs in young children and often still affects them well into adolescence-it is not the rule that they "grow out of it". Poor academic performance is associated with clumsiness in perceptual-motor skills such as constructing models, writing, hopping, cycling, and throwing or catching a ball. Van Dellen and Geuze (1988) say that the slow and inaccurate performance of clumsy children may be due to cognitive central motor response processes, salient in all motor skills. Information processing deficits specific to proprioceptive modalities seem to exist in them, together with difficulties in the visual perception of distance and spatial relationship. Generally, they "cannot make their hands do what their eyes see"; Van Dellen and Geuze found that in a choice reaction time task clumsy children were slower in choosing the correct response, but were not necessarily inaccurate.[276]

Lord and Hulme (1988) conclude that in a rotary pursuit task, clumsy children were inferior in performance to normals, visual feedback and the development of motor programs being the areas where performance was least comparable.[277] There seems to be an association between poor performance at mathematics and clumsiness, or so claims Professor Diane Parham, University of Southern California, who studied the academic progress of 67 children for four years; she found that those who were liable to injure themselves in woodwork classes or fall over often on the sports field, or had difficulty tying their shoelaces, were poor at arithmetic and geometry.[278] Such reports indicate that right hemisphere mechanisms responsible for spatial orientation, visual perception, sense of direction and mathematics of the more geometrical sort, together with the proprioceptive and motor program learning areas must all be affected by a lowered efficiency possibly brought about by very early developmental slowing or general low grade damage. It has been observed that artists are slow in speed tests;[279] however, they clearly require visual-spatial skills, and they perform those at above the norms, with especially the female art students excelling in this area. As females are usually less proficient at visual-spatial tasks than males, this is a notable finding; however, they did not surpass the male art students. It may be that the clumsy will show a lower than normal ability in such tasks in cognitive tests.

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[276] Van Dellen, T., and Geuze, R.H., Motor Response Processing in Clumsy Children, **Journal of Child Psychology and Psychiatry,** Vol. 29, No. 4, 489-500, 1988.

[277] Lord, R., and Hulme, C., Patterns of Rotary Pursuit Performance in Clumsy and Normal Children, **Journal of Child Psychology and Psychiatry**, Vol. 29, No. 5, 691-701, 1988.

[278] Logan, C., Clumsy children "worst at maths", **Sunday Express**, 16/12/90.

[279] Getzels, J., and Csikzentmihalyi, M., **The creative vision: a longitudinal study of problem finding in art**, New York: Wiley, 1976.

GESCHWIND AND GALABURDA'S TESTOSTERONE THEORY: A SUMMARY

To clarify the complexities of Geschwind and Galaburda's correlatory theory, McManus and Bryden (1991) have reduced it to a basic 30 Postulates, relating these to the pages in Cerebral Lateralisation (1987) where support for them is to be found. They are:

Testosterone Postulates:

Postulate One) Individual differences in testosterone levels are the principal common cause of a range of individual differences, modifying among other things the developing brain and immune system [pp. 11, 13, 107];

Postulate Two) The principal determinant of testosterone levels is the H-Y antigen, which determines maleness; the gene for beta-2-microglobulin on chromosome 15 may also be necessary for H-Y expression and be involved in familial dyslexia [pp. 11, 105, 107, 119];

Postulate Three) Testosterone levels are under direct genetic control, both in males and females [pp. 87, 88];

Postulate Four) Altered tissue sensitivity to testosterone can occur in both female and male foetuses and may be under genetic control [pp. 13, 107, 108];

Postulate Five) There are loci in the major histocompatability complex that alter the production and metabolism of testosterone [pp. 93, 94, 119];

Postulate Six) Testosterone levels will be higher in individuals, male or female, who have a cotwin who is male, and therefore also secreting testosterone [pp. 141, 142];

Postulate Seven) There is cyclic variation in sex hormone production, which can explain the higher rate of birth of individuals with particular syndromes at different seasons [pp. 218, 219, 220, 221];

Postulate Eight) "An anomalous endocrine environment in pregnancy might modify the later hormonal characteristics of the individual..."{C.L. p. 93} [pp. 141, 142].

Neurological Effects:

***Postulate Nine*)** In foetuses, testosterone "...slows the growth of parts of the left hemisphere, so that...the corresponding regions on the right develop relatively more rapidly" {C.L. p. 11} [pp. 11, 46, 98, 99, 100, 207];

***Postulate Ten*)** Delayed left hemisphere growth results in a disruption of the normal cortical architecture of the left-hemisphere [pp.13, 58-66, 86, 121, 186, 199, 202];

***Postulate Eleven*)** Delayed left-hemisphere growth is associated with an increased incidence of the conditions broadly called "developmental learning disorders" [pp. 83, 84, 87];

***Postulate Twelve*)** Delayed left-hemisphere growth results in "anomalous dominance" [pp. 70, 73];

***Postulate Thirteen*)** Individuals with anomalous dominance should have higher rates of recovery from aphasia [p. 74];

***Postulate Fourteen*)** Delayed left hemisphere growth results in a smaller left hemisphere, which in turn results in decreased verbal ability. However, other factors, such as a longer pregnancy, delayed puberty, or the absence of growth retardation can result in a lengthened growth period so that, despite growing more slowly, the left hemisphere can be larger and hence verbal ability be greater [pp. 94, 98, 99];

***Postulate Fifteen*)** Delayed growth of the left posterior hemisphere "...favours growth of cortical regions on the opposite side and of unaffected regions of the same side." [pp. 12, 65, 66, 97, 98, 99, 102];

***Postulate Sixteen*)** Compensatory right hemisphere growth typically results in "giftedness" for those skills for which the right hemisphere is particularly involved [pp. 11, 77, 78, 82, 87, 98, 168]:
a) Mathematical ability;
b) Artistic and/or Spatial ability;
c) Athletic, dancing and other motor skills;
d) Musical ability.

***Postulate Seventeen*)** Testosterone delays the growth of the anterior part of the right hemisphere [pp.20-34, 206, 207];

***Postulate Eighteen*)** Alteration in the relative activities of the right and left hemispheres, caused by left hemisphere growth retardation and right hemispheric hypertrophic compensation, alters the hemispheric balance, producing anomalous and idiosyncratic responses to psychoactive drugs [pp. 213, 214];

Postulate Nineteen) "Alterations in hemispheric dominance relationships..." result in "...lateral imbalances produced in normally symmetrical neural systems, '...resulting in vestibular anomalies and conditions such as motion sickness [p. 151].

Immune Effects:

Postulate Twenty) Testosterone in utero has the effect of retarding the development of the immune system [p. 13];

Postulate Twenty-one) Retardation of the immune system increases susceptibility to immune disorders in prepubertal males [pp. 13, 88-89, 118, 123];

Postulate Twenty-two) Testosterone suppresses the thymus in adult life, postpubertally [pp. 13, 122];

Postulate Twenty-three) Thymic involution in adults in response to testosterone results in a lower incidence of immune disorders, especially in males [pp. 13, 92, 96, 118, 122, 123, 196];

Postulate Twenty-four) Abnormalities of immune functioning should result in a range of other conditions with actual or possible immune deficits [pp. 82, 91, 92, 124, 150, 175, 176, 180, 198]:
a) Infectious diseases;
b) Acquired immune deficiency (AIDS);
c) Malignancies of the lymphoid system;
d) Migraine.

Other Effects:

Postulate Twenty-five) There will be decreased rates of cancer [pp. 181, 182, 218];

Postulate Twenty-six) Testosterone alters the embryological development of the neural crest, resulting in a range of minor and major structural abnormalities [pp. 156, 157, 158, 159, 160, 161, 162, 163, 170, 177];

Postulate Twenty-seven) Testosterone in pregnancy can alter metabolic processes and result in adverse drug reactions [pp. 216, 217];

Postulate Twenty-eight) Testosterone can result in masculinisation in females both physically and behaviourally [pp. 111, 141, 169, 171, 172, 183];

Postulate Twenty-nine) High testosterone levels early in foetal development result in homosexuality in males [pp. 175];

Postulate Thirty) High testosterone levels are in some unspecified way the cause of birth complications and birth stress [pp. 176, 227].

The model constructed by McManus and Bryden obeys the first law of path analysis, they say, with coefficients which are non zero, variables correlating as nodes are traversed both backwards and forwards through the interlinking elements. McManus and Bryden draw attention to the concept of Anomalous Dominance (AD) to which Geschwind and Galaburda attach great importance, with reference to cerebral hemispheric dominance for different functions. AD is any pattern of dominance which differs from the norm of strongly right-handed, strongly left hemisphere language dominant, strongly right hemisphere visuospatial dominant, such as reversed or any other combination of left or right language/hand/visuospatial dominance which differs from the norm. Geschwind and Galaburda assume continuously distributed degrees of language and visuospatial lateralisation and handedness.

McManus and Bryden criticise the concept of AD as over-inclusive, producing the likelihood that some 60% or 70% of the population could be classified as AD! They say the concept may be too imprecise to be scientifically useful. It follows that what may be required is a test which analyses the finer gradations of difference in the various AD configurations (such as the test used in the present study). They describe Geschwind and Galaburda's theory as an environmental model, as its authors were firm in arguing that the number of non-genetic factors involved in the determination of laterality was so large that no purely genetic theory could adequately deal with them. Overall they conclude that, while the concepts and claims of the testosterone theory seem dangerously over-inclusive, it seems a valuable generator of fresh hypotheses, such as those used in this research.[280]

THE SAVANT

Geschwind and Galaburda's theory could clearly be used to cast some light on the causes and nature of the 'idiot savant', individuals of special interest to the present writer. They will, therefore, have a full chapter devoted to them, and especially the artistic savant.

[280] McManus, I.C., and Bryden, M.P., Geschwind's Theory of Cerebral Lateralisation: Developing a Formal, Causal Model, **Psychological Bulletin,** Vol. 110, No. 2, pp. 237-253, 1991.

FIGURE TWO: Self-Portrait by Andrew, an Edinburgh artist (aged 26), 1990

Popular Interest

The artistic savant is ill-understood. The greatly increased number of articles and papers with the autistic savant as their subject since the enormous success of Dustin Hoffman's ***Rain Man*** and the showing of BBC2's programme on ***The Foolish Wise Ones*** , which first brought Stephen Wiltshire to prominence, has evidenced some jumping on to a rolling bandwagon. Such publicity has been both good and bad: on the one hand, it has caused many parents and professionals to look more closely at the youngsters in their care who may be handicapped and yet have some singular talent, while others have been frightened by the dangers of possible exploitation into resisting any research. The general public and the tabloid press have a tendency to turn savants into side-show freak curiosities, and parents of such children know this only too well.

Problems With Definition And Explanation

LaFontaine defined the idiot savant as an individual with a low IQ, usually around 50 to 70, who exhibits some unusual talent to a marked degree. The talent may be that of calculating ability, unusual memory, or special musical or artistic ability.[281] Darold Treffert, in his survey of the savant,[282] writes that the condition can be congenital and present at birth, or acquired and develop in an otherwise normal person following injury or disease of the CNS, and that it develops in more males than females in a ratio of 6:1. He further expands the catalogue of areas of savant skill to include mechanical ability and unusual sensory discrimination.[283]

The savant is an uncomfortable phenomena to have around: it appears to be a living refutation of Piagetian stage theories of development, because it demonstrates a single area of skill or ability in a wasteland of non-ability, something the lock-step of age-linked cognitive development cannot explain; too, it mutely rebukes the believers in "g", that ineffable quality normally given to us all in varying degrees at birth by the Good Fairy, and which enables us to score well or less well on IQ tests. Some IQ tests, such as the WISC-R, contain sub-tests on which low *overall* scorers do very well; autistics appear to score moderately highly on the visual-spatial sub-tests and poorly on the verbal tests, as do dyslexics. The dyslexics show a reduced digit-span ability, which is more or less the ability to memorise telephone numbers spoken to them. Gestalt form completion tests, the viewing of partially rubbed-out drawings and the use of imagination to say what they are, appear to be measures of a very typical right-hemisphere function. Drs O'Connor and Hermelin at the University of London found that their artistic savants scored more highly on a Gestalt test than did matched normal artistically talented children.[284] To help explain such results, Neal O'Connor has espoused the concept of modularity in intelligence, where, rather than being a homogeneous whole, "g", our intelligences

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281 LaFontaine, L., Divergent Abilities in the Idiot Savant, Doctoral Dissertation, Boston University, 1974.

282 Treffert, D.A., **Extraordinary People: An Exploration of the Savant Syndrome**, London/New York, Bantam Press, 1989.

283 p.xxvi, **Ibid.**

284 O'Connor, N., and Hermelin, B., Visual and graphic abilities of the idiot-savant artist, **Psychological Medicine**, 17, pp. 81-92, 1987.

are made up of a heterogeneous collection of cognitive systems. This conception more easily accommodates the phenomena of the savant.[285]

The French term, "idiot savant", is thought to have been used for the first time in 1887 by Down; at that period, "idiot" had a specific sense: it was part of a hierarchy of retardation which included "cretin" and "moron", and when "feebleminded" was still an acceptable term to use about those who were cognitively low functioning. "Idiot", after the advent of Binet and IQ tests, attained a rigid definition as referring to someone having an IQ of below 25, while "savant" is a learned or knowledgeable person. The two words combined create what is known as an "oxymoron", a combination of contradictory or incongruous words. Indeed, the figure of speech itself is the English version of "idiot savant", from the Greek *oxys* =sharp, keen, and *moros* =foolish. In dictionaries, the usual example given of such a figure is "the wisest fool in Christendom".[286] Whoever created the name showed great wit by using the French version of a Greek-derived English figure of speech to name a clinical category! Down used "idiot savant" in the same Lettsomian Lectures in which he gave the most accurate description of the syndrome which bears his name, but expressed reservations about the unpleasant term "idiot". His actual words were:

...an interesting class of cases for which the term "idiots savants" has been given...[287]

which seems to indicate that the term's author was not Down.

The BBC2 TV program six years ago translated the term literally as "Foolish Wise One", and introduced to the general public an autistic calendar calculator, together with Noel Pattison, an autistic pianist with almost perfect memory for melody, and Stephen Wiltshire, a handicapped boy able to reproduce from memory the detailed architecture of the London skyline. The assumption is often made, even by psychologists who ought to know better, that all savants are autistic; evidence to refute this assumption is given by LaFontaine (1976), who reports a 29-year-old male diagnosed as having Downs Syndrome who had artistic talent of a rare order, a musical savant who suffered brain damage through infantile illness, and a blind and mentally handicapped female who was a calendar calculator. Morishima and Brown (1976) have reported on a hydrocephalic artistic savant, Yoshihiko Yamamoto,[288] Phillips has studied a microcephalic savant,[289] while Hill has investigated a calendar calculating savant suffering from congenital syphilis.[290]

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[285] O'Connor, N., Intelligence, Handicaps and Talents, **The Mental Retardation and Learning Disability Bulletin**, 15, {2}, pp. 41-56, 1987.
[286] p.1051, **Longman Dictionary of the English Language,** 1984.
[287] quoted in Treffert, p. 3.
[288] Morishima, A., and Brown, L.F., An idiot savant case report: A retrospective view, **Mental Retardation**, 14, pp. 46-47, 1976.
[289] Phillips, A., Talented Imbeciles, **Psychological Clinic**, 18, pp.246-255, 1930.
[290] Hill, A.L., An investigation of calendar calculating by an idiot savant, **American Journal of Psychiatry,** 132, pp.557-560, 1975.

Duckett thoroughly examined diagnostic classifications of savants, reporting that of the 25 cases she examined the diagnoses covered four different prenatal, two perinatal, and four postnatal causes of cognitive deficit, [291] concluding that the behavioural characteristics of the savant are not related to specific aetiologic causes, and certainly that they are not always autistic. It has been suggested that because the diagnostic classification of autism is sometimes disputed as legitimately different from that of childhood schizophrenia, and because sometimes the autistic have high IQ scores, the talents shown by autistic savants are somehow less remarkable than they appear. No identified savants in the literature have even normal IQs; however, the Edinburgh savant, Andrew, researched by the present writer, has an IQ which fluctuates from 40 to 115!

Lorna Selfe has studied the savant in the visual arts; she discovered Nadia Chomyn, the four-year-old autistic artist,[292] and others since.[293] Her conclusion that autistic artists are made possible by the poverty of their language abilities lacks conviction, simply because all autistics by that criterion ought to be excellent artists, and very few are. Selfe cites Nadia's apparent loss of interest and skill in art as her language abilities developed under remedial attention as a proof of the nature and origin of her artistic talent; however, Stephen Wiltshire, who appears to thoroughly enjoy the attention he and his drawings receive, and whose linguistic capacity has grown steadily *together* with his art, seems to disprove Selfe's theory. Over and over again, writers claim that savant abilities derive from some aspect or another of their pathology-what Rimmer has called "The cow-pat hypothesis".

Those who have studied savant artists in an institutional setting have come up with explanatory theories biased by the setting: LaFontaine[294] and others of a similar "social" leaning[295] write rather vaguely about social and psychological isolation, sensory deprivation, leading to greater sensitisation to stimuli, which in some is directed toward visual stimuli and their reproduction in art. Professor Anthony Storr has written a wise book on the solitary genius, and how a measure of isolation is probably essential for the most creative thought, which one could call "The Greta Garbo" hypothesis.

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291 Duckett, J.M., Idiot Savants: Super specialization in mentally retarded persons, Doctoral Dissertation, University of Texas at Austin, 1976.
292 Selfe, L., **Nadia: A Case of Extraordinary Drawing Ability in an Autistic Child**, London, Academic Press, 1977.
293 Selfe, L., **Normal and Anomalous Representational Drawing Ability in Children**, London, Academic Press, 1983.

294 Lafontaine, L., Divergent abilities in the idiot-savant, unpublished Ed.D. dissertation, Boston University School of Education, 1974.
295 Duckett, J., Idiots-savants: superspecialization in mentally retarded persons, Doctoral dissertation, Austin, University of Texas, 1976.

Unfortunately, this does nothing to explain those artistic savants who grow up in a stimulating, caring family environment, or those Renaissance artists who turned out masterpieces in their crowded bottega, or artists such as Picasso and Braque, "two mountaineers roped together", as they climbed the semi-abstract peaks of Cubism. By this reasoning our prisons and hospitals ought to be throbbing with creative energy. No-one has explained why only a very small number derive such unexpected benefits from these various factors, and what it is which distinguishes *them* from all the rest, who benefit not a jot.

Other writers choose to examine closely the nature of the skill or talent, usually concluding by ascribing the cause of savant status to some aspect or another of the artistic ability itself! Savants are characterised as having unusually powerful visual memories, or great strength of concentration, complex fine motor abilities, or to have benefited from having had a strongly motivating significant other. A cursory look at the history of art would have shown these authors that all artists, great or just run-of-the-mill, are characterised by those things: Michelangelo had virtually a photographic memory for all of his own works and for those of competing artists; the ability to lose oneself in the production of a painting or drawing is found in good artists; the ability to use the tools of the trade-brushes, pencils, burens, palette knives-with fine precision is an essential artistic skill, and no artist has achieved anything without the motivating parent, teacher, master artist in the workshop or studio, or competing peers. It will not do to describe some aspect of what is necessary to be an artist and believe one has explained the artistic savant.

It certainly seems that not only is there no consensus on an explanation for the artistic savant, but that existing explanations demonstrate a sad lack of rigorous analysis. Non-explanations are repeated in slightly differing forms, using different jargon, when writers in the field find themselves pushed to attempt an explanatory theory. Darold Treffert, in an otherwise good review of the savant literature,[296] devised one of the several "biological" theories, which seeks to describe autism as deriving from pre- or peri- or post-natal ischemic-hypoxic injury, which inhibits the normal development of the associative areas of the left hemisphere of the brain; there is, as well, damage to the amygdala, a lower brain structure, leading to over-reliance on right hemisphere, so-called "concrete" abilities, and a hyperfunction of another lower brain structure, the hippocampus, an organ responsible for many memory functions. This is simply Lorna Selfe's hypothesis wrapped up in neurophysiological ribbons, and it has the same glaring fault: it may explain the physical basis of autism (and recent brain scans seem to have cast doubt on even that), but it cannot give us the reason for the existence of the artistic savant, who, as we know, need not necessarily be autistic.

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[296] Treffert, D.A., The Idiot Savant: A Review of the Syndrome, **American Journal of Psychiatry**, 145, 5, May, pp. 563-572, 1988.

Glyn Thomas and Angele Silk, in their recent book on children's drawings,[297] offered a chapter on the autistic savant artist, in which there was a review of the major theories; they finally settled for the Selfe hypothesis: that artistic skill was "caused" by language disability. It must be obvious to most people that artists are not wholly language disabled or even learning disabled, as a rule (although some may be; see preceding chapter). It is clear that the problem confronted by all such writers is that they know little about what it is to be an artist-the artist must seem as inexplicable to them as the autistic child; when confronted with the two-in-one, their confusion is redoubled.

When psychologists venture into the history of the arts, inevitably they make blunders: for instance, Thomas and Silk claim that there is no evidence in child artists of the sort of precocity shown by Mozart, composing at four years-however, the present writer's research has uncovered excellent profile pencil portraits from the life done by the five-year-old who was to become Sir Thomas Lawrence, President of the Royal Academy.

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[297] Thomas, G., and Silk, A., **An introduction to the psychology of children's drawings**, Harvester Wheatsheaf, 1990.

Mrs. later Lady, Kenyon (1741–1808)
Pencil on paper. 30.5 × 18.8
Signed: *T. Lawrence/Fecit*

Lloyd Kenyon, (1732–1802)
Pencil on paper. 30.5 × 18.8
Signed: *T. Lawrence/Fecit*

FIGURE THREE: PORTRAITS BY THOMAS LAWRENCE, AGED FIVE

They may not be masterpieces [**FIGURE THREE**], but then who now plays the compositions of the four-year-old Mozart? Both Lawrence and Mozart did not become truly accomplished until well into adolescence .

It seems fairly clear that there is no field of cultural activity in which work of genuine quality is achieved before an apprenticeship of at least ten years has been passed.[298] This must be the case for the savant, as well.

Repeatedly, writers such as Thomas and Silk describe savant artworks as "lacking in emotional qualities", or "deficient in symbolic values", or "without interest or skill in depicting human beings". These supposed typicalities can easily be shown to have exceptions which cast doubt on their validity. In the same way that musical savant's performances, such as those of Leslie Lemke or Noel Pattison, are said to be without

[298] Feldman, D.H., **Beyond Universals in Cognitive Development,** Norwood, NJ, Ablex, 1980.

emotional light and shade, so the autistic artist who draws people is alleged not to show them as emotional beings. It is possible to suggest that human beings are among the most difficult subjects to master, requiring great technical skill and much practice-art students interviewed often confess they dread life classes. To convey personality, individuality, emotion is even harder-it is much easier to draw the Forth Rail Bridge, as Edinburgh savants do. It is particularly unfortunate that Thomas and Silk single out Nadia as an example of an artistic savant who did not draw humans, when even the most cursory examination of her work would reveal dozens of drawings of horse riders, together with studies of people, including Lorna Selfe, taken from the life [see **Appendix V**].

An associated typicality is that autistic artists are not interested in colour;[299] colour is regarded as an expression of emotion, which it is said autistics cannot understand. The present research has found autistic artists who are superb colourists, who create forms out of layers of colour, and are sensitive to such things as the cold hues necessary to convey Russian snows, and the hot oranges and yellows of Caribbean scenes. Contrary to the generalisations of authors such as Thomas and Silk, all savant artists are not linear, they are not confined to black-and-white drawing, as is Nadia. Another claim is that, once locked into a medium, they cannot change; because of obsessional adherence to a preferred instrument, such as Nadia's ball-pen, they cannot or will not use anything else. Ongoing research disproves this claim, some savants using varied media for artistic expression, such as the Edinburgh savant Andrew; even Stephen now has moved quite easily away from his preferred pencil to the use of wash and colour.

Thomas and Silk make the claim that no-one has found out if autistic artist's pictorial development follows the same route as that of normal children, the Rhoda Kellogg/Viktor Lowenfeld scribbling, tadpole, house, dog, train progression supposedly followed by all. A problem with autistics is that quite often, rather than being given paper and crayon or pencil, they are given slates and chalks, things with less danger value. Who knows whether or not those long-erased slates ever showed mandalas, tadpoles, or pseudo-Piagetian stages of artistic development? The current research has picked out very clear artistic progression in artistic savants, sometimes moving away from obsessional subject matter to a greater breadth of interest, but usually showing rapidly improving technical expertise and sensitivity. If they do move through developmental stages in their art, it is a greatly accelerated progression, in much the same way the high IQ young artist speeds through to detailed, naturalistic, perspectival work. Perhaps this very speed deceives observers into concluding that savant artists are slaves to reality. They may arrive at the so-called stage of conventional realism much more quickly than the normal child.

In this connection, Ellen Winner, the author of a book on the psychology of the Arts, stated that:

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299 p. 135, Thomas and Silk.

...the autistic child prodigy appears to have no choice but to represent in an optically realistic style. In lacking the freedom not to draw naturalistically, and in thus lacking full control of the artistic product, the autistic child prodigy never reaches the end state of artistic development.[300]

This does not seem to be always true: the present writer's research has encountered a savant artist who produced surreal visions of giant flying Japanese tea-cups over cloud-shrouded mountains, of Shaking Stevens perched precariously on a saddled horse-back while his female singers are reduced to paired smiling faces in a fog, or compiled a painting out of many photographs of Ecuador in a true creative synthesis; another paints biomorphic semi-abstract shapes, suggesting human beings and animals by the use of thick, black outlines and primary colours to give a "stained-glass window" effect: in no sense are these works "viewer specific" or "slavishly naturalistic".

Furthermore, since the Renaissance and, historically, until only very recently, artists have consistently striven to represent reality accurately; only with the advent of photography and the contemporaneous growing concern with the inner world of the unconscious and dreams did it become permissible to paint unrealistically. The artist's task to represent reality had been usurped by a machine, leaving only the landscapes of the mind and its stranger abstractions to paint. We have been conditioned by several generations of artists and critics to see abstract art and surreal art as somehow superior to what went before, even perhaps as evidence of our attainment of some cultural Piagetian stage of formal relations, the ability to manipulate abstractions meaningfully. At last, we have reached cultural adolescence! Mondrian and Frank Stella are therefore superior to Leonardo and Botticelli, Picassos and Rothkos more meaningful than Durers and Raphaels. This strange reasoning, born of the displaced role of the artist in modern times and the desire to convince potential buyers such works are at the leading edge of the avant garde, leads, especially in America, the birthplace of Abstract Expressionism, to a condescension towards the figurative-it is, or has been until relatively recently, regarded as being somehow dated, primitive, and immature art. So, when savants produce realistic or naturalistic artworks, ipso facto, it is seen as evidence of their pathology, their immaturity as artists, rather than as evidence that they belong to a realistic tradition which began some 600 years ago.[301][302] The causes of savant mental

[300] p.191, Winner, E., **Invented Worlds: The Psychology of the Arts**, Boston, Mass., Harvard University Press, 1982.

[301] Michael Howe is another writer who repeats the same received knowledge: of Lorna Selfe's savant artists he states they "...demonstrated an exceptional ability to depict objects realistically...", that Nadia from the age of three was producing "...drawings of animals...", that she had not excluded normal children from her search, and, indeed, that they were all children she had examined {p. 196, Howe, M., The Strange Achievements of Idiots Savants, **Psychological Survey 7**, 1990.} These claims are wrong: more than one of Selfe's savants drew human beings in a most non-naturalistic fashion, not just objects; Nadia produced drawings of people as well as animals; normal children were searched for

disablement may be many, nevertheless the talent is singular. However, some may have more than one skill, and so the following definition by Hill is widely considered accurate:

A savant is a mentally retarded person demonstrating one or more skills above the level expected of nonretarded individuals.[303]

This definition needs refining, so the present writer offers a three-level categorisation of savants:

1) mentally and/or physically disabled individuals with one or more skills clearly above the general level of their cognitive functioning, although not reaching normal age levels;

2) mentally and/or physically disabled individuals with one or more skills above the general level of their cognitive functioning in which good, normal ability for their age is attained;

3) mentally and/or physically disabled individuals with one or more skills so far above the general level of their cognitive functioning and that of any normally skilled person of their age that prodigious and outstanding ability is displayed.

These more finely calibrated definitions give a taxonomy better able to classify the levels of savant talent and the differential with other cognitive abilities.

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before the time she was looking for savants, and Richard, one of those she included with her children, was so far from being a child that he was in fact twenty-six years old at the time of publication! It is open to debate how fair it was to include him in research examining the anomalous graphical representation of children..... Another reason why doubts should be cast on his inclusion in Selfe's sample is that the drawings used by her to illustrate his preference for black-and-white graphical representation are only black-and-white in the reproductions in her book-the originals, seen by the present writer, are very brightly coloured.

302 Rimland and Fein, in Rimland, B., and Fein, D., Special Talents of Autistic Savants, {pp. 474-492, L.K. Obler and D. Fein <eds.>, **The Exceptional Brain: Neuropsychology of Talent and Special Abilities,** New York-London, The Guilford Press, 1988} state that Richard has autistic features but cannot be called truly autistic, that his speech was intelligible only to those who listened to him carefully, and that he was like Nadia in that he was born in Scotland of Polish parents. In the first instance, Richard is old enough now to have compensated very well for many of his early autistic symptoms, while his troubled childhood behaviour would have amply satisfied the DSM-III criteria for autism; the emotional rewards he has received for his artistic success have buried many of his earlier tensions and anxieties-obviously he seems less autistic now. Secondly, his speech is by no means hard to understand, it is simply lacking in conjunctions and general syntax, a variety of "telegraphese". Thirdly, Nadia was of Ukrainian parentage, not Polish, and was born in Nottingham, not Scotland.

303 p.281, Hill, A.L., Savants: Mentally Retarded Individuals with Special Skills, pp.277-302 of the **International Review of Research in Mental Retardation**, edited by Norman R. Ellis, Vol. 9, Academic Press, New York, San Francisco, London, 1978.

Savant Statistics

Hill has calculated from a survey carried out by him in 1977 that from a total population of 90,000 mentally retarded individuals in 300 public residential facilities in the United States the 54 identified savants represented a rate of incidence of approximately .06%, or 1 in every 2000 residents.[304] He surveyed the literature between 1898 and 1974, finding 52 reports of savants.[305] In 1978 the same author made another survey of the literature, concluding that of 105 individuals classified as savants within 63 publications, 89 were males, 14 were female, while two were of indeterminate gender. It seems that there is a strong relationship between the sex of the individual and the development of a special skill.[306]

As stated above, Treffert found a male-female ratio of 6:1. He puts the incidence of savants in patients with Early Infantile Autism at 9.8%; however, EIA itself is rare, occurring only 7 times on average in every 100,000 children. Nevertheless, this places its incidence in such rare children much higher than Hill found in the institutionalised developmentally disabled population. Rimland[307] used his case registry of 5,400 autistic children world-wide to derive 531 (9.8%) with special abilities; he found a sex ratio of 3.54:1, almost exactly that of autism itself.

On following-up 119 of these special ability autistics, Rimland found that 63 (31.7%) had musical skill, usually together with phenomenal memory. Treffert notes that musical skill in both the autistic and non-autistic savant is very often found with blindness or very severe visual impairment. The triad of blindness, musical skill, and mental handicap seems most often found after premature birth, and particularly in those individuals who were given excess oxygen, now known to be the primary cause of retrolental fibroplasia.[308] Another cause of visual defect, chorioretinitis, is associated with mental deficiency, and is transmitted as a Mendelian recessive gene; it is the association observable in the calendar calculating twins, George and Charles, producing a degenerative myopia.[309] Retinitis is often associated with hearing problems, as well; savants have frequently been found to have right and/or left side hearing deficit, particularly in the higher register. Obviously, this cannot be the case in those musical savants with perfect pitch. Perhaps the possession of normal hearing and pitch discrimination may incline

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304 Hill, A.L., Idiot Savants: Rate of Incidence, **Perceptual and Motor Skills**, 44, pp.161-162, 1977.

305 Hill, A.L., Idiot Savants: A categorization of abilities, **Mental Retardation**, 12(6), pp.12-13, 1974.

306 Hill, A.L., Idiot Savants: Sensory/Motor deficits and gender, **International Journal of Rehabilitation Research**, 1(1), 1978, pp. 81-83.

307 Rimland, B., Savant capabilities of autistic children and their cognitive implications, in G. Serban, editor, **Cognitive Defects in the Development of Mental Illness**, New York, Brunner/Mazell, 1978.

308 Treffert, **Extraordinary People**, p. 34.

309 Holstein, A.P., discussion of Horwitz, W.A., Kestenbaum, C., Person, E., and Jarvik, L., Identical twin-idiot savants-calendar calculators, **American Journal of Psychiatry**, 121, pp. 1075-1079, 1965.

some cognitively disadvantaged individuals to music as an area of skilled achievement, while the artistic or calendar calculating savant may more often be found to have a hearing disability. Further research must attempt to settle this question.

One of the frequently repeated denials in the literature is that savants are almost never true "idiots", and usually have IQs above 50, as. for example, in Griffith Steel, Gorman, and Flexman (1984):

The term idiot-savant is a misnomer: most are actually morons or borderline (IQ 50-74) and not idiots (IQ 25).[310]

However, Treffert draws our attention to A. Dudley Roberts' 1945 account of a 27-year-old male mentally handicapped and almost wholly physically paralysed by encephalitis at six months who was judged to have an IQ of 8. Classified as a helpless idiot, by using facial twitches and smiles he was able to name the day of the week for any date from 1915 to the present.[311] In 1941, Owens and Grimm reported on a female with a measured IQ of 23 who had perfect pitch and was able to play competently on the piano any piece sung or hummed to her.[312]

Richard Wawro's IQ was estimated at 30,[313] while some of Hermelin and O'Connor's savants were measured at below 40.[314] At 12 years, Yoshihiko Yamamoto, the Japanese artistic savant, had an IQ measured at 23.[315] One of LaFontaine's savants had an IQ of less than 30, but could read at the sixth grade level (hyperlexia).[316] In their early development, most savants have tested at quite low levels of IQ, if not within the old category of "idiot" at least not much above; with time and the exercise of their special talents, IQ scores invariably increased, perhaps with some sub-test scores being enhanced by the greater development of capacities associated with and integral to their particular talent. Researchers should cease to attempt a narrowing of the IQ range of savants to the relatively higher levels of 50-70, because the facts speak otherwise. IQs in the 20s **are** to be found amongst idiots

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310 p. 704, Griffith Steel, Major J., Gorman, Lt. Col. R., and Flexman, J.E., Neuropsychiatric Testing in an Autistic Mathematical Idiot-Savant: Evidence for Nonverbal Abstract Capacity, **Journal of the American Academy of Child Psychiatry**, 23, 6, pp. 704-707, 1984.

311 Roberts, A.D., Case history of a so-called idiot-savant, **Journal of Genetic Psychology**, 66, pp. 259-265, 1945.

312 Owens, W.A., and Grimm, W., A note regarding exceptional musical ability in a low grade imbecile, **Educational Psychology**, 32, pp. 636-637, 1941.

313 p. 88, Treffert, **Exceptional People,**

314 Hermelin, B., and O'Connor, N., Idiot savant calendrical calculators: rules and regularities, **Psychological Medicine**, 16, pp. 885-893, 1986.

315 Morishima, A., Another Van Gogh of Japan: the superior work of a retarded boy, **Exceptional Children**, 41, pp. 92-96, 1974.

316 Spitz, H.H., and LaFontaine, L., The digit span of idiot savants, **American Journal of Mental Deficiency**, 77, pp. 757-759, 1973.

savant. Of course, by stating that savants are usually more intelligent than the name would suggest, the skills they demonstrate may be made to seem a little more explicable.

Methods Used In Savant Testing

Despite what has been said concerning savant IQ scores, most paper-and-pencil tests only go so far as proving that savants are not very good at tests. IQ measures below 70 are known to be unreliable and in the face of such low-level cognitive abilities and often even lower levels of motivation for being tested, most test scores of savants have had to be estimated, and sometimes very roughly. Doubts ought to be cast on the value of such figures.

At the age of 4.5, Nadia Chomyn, the well-known artistic savant from Nottingham was classified as severely sub-normal; however, when one of her drawings of the human form from that age was scored on the Goodenough-Harris "Draw a Woman: Assessment" test she emerged with an IQ of 160![317] Hermelin and O'Connor used the Goodenough-Harris test with 5 idiots savant (1987), but suspected that it lacked reliability and cast doubts on its standardisation with other tests of IQ, such as the Columbia Mental Maturity Test.[318] If, however, the concept of a general IQ is abandoned, such tests may be useful in estimating levels of ability solely within independent cognitive modules, which may develop relatively untouched by whatever neural devastation has occurred elsewhere.

Areas where testing appears to have been useful are those concerning spatial ability: Luszki (1966) indicated that while the WAIS Performance Scale score of James, a 32-year old deaf-retarded patient, showed an IQ of 76, his scores on two of the sub-tests, Block Design and Object Assembly, would have given him an overall IQ of 127!.[319] Other researchers in more recent years have shown that in spatial ability paper-and-pencil testing of savants shows reliable and uniform high scoring, perhaps the only area in which such testing is reliable. Savants resemble us all in being quite happy to be tested on something they enjoy doing.

317 p.12, Selfe, L., **Nadia: a case of extraordinary drawing ability in an autistic child**, Academic Press, London, New York, San Francisco, 1977.
318 O'Connor, N., and Hermelin, B., Visual and graphic abilities of the idiot savant artist, **Psychological Medicine**, p. 3, 7, 1987.
319 Luszki, W.A., An Idiot Savant on the WAIS?, **Psychological Reports**, 19, pp. 603-609, 1966.

Comparison Of Case Studies;

Nadia Chomyn was a second born child in a family of three children, her parents being Ukrainian. At twelve months her developing language began to fade away, until by six years she possessed a vocabulary of approximately ten single-word utterances, and those hardly used at all. She spent much of her time staring into space, was very poorly co-ordinated and slow-moving. Unresponsive to question or command, it was difficult to know whether she lacked comprehension or was simply refusing to cooperate. At 3.5 years, and during the time when she was separated from her hospitalised mother, Nadia began to draw with what became her sole instrument, a ball pen, producing extraordinary drawings which displayed the manual dexterity which was notably absent in all other areas of her functioning.[320] The drawings were finely detailed, in perspective, accurately proportioned, using occlusion and hidden-line elimination. They were vital and energetic, and were totally different from those drawings normally produced by children of her age. Not only were they different from but also they were manifestly superior to those of any normal three or four year-old [see **Appendix V**]. It appears from the series of studies of savants carried out by Drs Hermelin and O'Connor that all savants are not equal-Nadia, Andrew, and Richard may be considered to rank in the First Division of artistic savants with regard to representational ability, while the majority of individuals studied by the London University researchers appear to belong in the Second Division.

The major exception, of course, is Stephen Wiltshire, born in 1974, and one of the savants shown in the "Foolish Wise Ones" film. His talent clearly places him above Nadia in the League Table.[321] Like Nadia, Stephen draws mostly from memory, the inspiration coming from real life buildings in his case and primarily picture books in her case. She could draw from life, but preferred to study her Ladybird books with intense attention, memorising the details there, reproducing them weeks later. Stephen, too, studies architectural details from both photographs and life very intently, storing them for later use. Although not short-sighted, Nadia used to peer very closely at the pictures she wanted to store, nose quite close to the page. Richard **is** short-sighted, and he does exactly the same, studying the photographs of far-away places which fascinate him and which he will reproduce in wax crayon sometimes months or even years later. Andrew's sight is normal, but he, too, peers closely at his own and others' photographs while drawing and painting [**FIGURE TWO**]. Richard shares with Oliver Sack's Jose a delight in magazines such as ***The National***

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320 Luszki's savant occupied himself by unravelling pieces of cloth, some savants, according to Hill, are able to peel apart the laminated layers of sheets of paper, while others can apparently tie knots in eyelashes!

321 O'Connor, N., and Hermelin, B., Visual and Graphic abilities of the Idiot Savant Artist, **Psychological Medicine**, 17, 1987 and O'Connor, N., and Hermelin, B., Visual Memory and Motor Programmes: Their use by Idiot Savant Artists and Controls, **British Journal of Psychology**, 78, pp. 307-323, 1987

Geographic, although Jose reproduces scenes from such publications only in line [see **Appendix V**].[322]

Myopia is a characteristic of a high proportion of savants: the degenerative myopia of the calendar calculating twins, about whom Oliver Sacks and many others have written,[323] requires them to wear glasses so thick that they appear to distort their eyes. LaFontaine reported two of her savants having to wear similar glasses [in her **Divergent Abilities in the Idiot Savant**], while Selfe's savants included two with cataracts from birth, and one with a squint. Nystagmus is present in Richard, as well.

Jose[324] is epileptic, autistic, aphasic after encephalitis at the age of eight; he has had since earliest childhood a skill in drawing which appears to have been spared when he suffered the high fever which damaged his brain.[325] His father had been fond of sketching, while his older brother was a successful artist. Jose's attention to naturalistic detail is every bit as precise as Richard's, although expressed in the pen line of Nadia, and is rather more controlled than that of Stephen. The institutionalised 25-year-old draws trout, people canoeing on a lake, scenes from Christmas cards, even reproducing textbook illustrations, while being able to draw a pocket-watch and a dandelion from life. In recent times he has extended his artistic and handicraft talents to producing mosaic and stained wood altarpieces for churches, and carved lettering on tombstones. Of course, when a notice is required in his ward, he is the one who is asked to produce it, complete with elaborate flourishes. What he shares with Richard, Stephan, and Nadia is the ability to take images from photographs or real life and alter their perspective, rotate them to a different view or position, include them in different compositions, in short, to do what all good artists are able to do, demonstrate visual imagination and creativity, qualities considered impossible in such handicapped and retarded individuals.

Yamamoto, too, suffered some hearing loss from the damage caused by his hydrocephaly. He began his artistic career by painstakingly copying black and white cartoons out of books and magazines, later being urged by his teacher in a special education class to use colour in his artwork. The teacher's persistence in trying to train the boy paid off, his art improving steadily. Born in 1948, Yamamoto lives near Nagoya City, and it was his drawing of Nagoya Castle [see **Appendix V**]which decided the teacher to encourage his pupil to use the print medium. The accuracy and clean lines of Yamamoto's drawings suited prints well, helping to purify his previously rather muddy colour. Soon, he was winning prizes and selling prints,

322 Sacks, O., The Autist Artist, **The New York Review of Books**, 32, April 25th, pp. 17-21, 1985.

323 Sacks, O., The Twins, **New York Review of Books**, 32, Feb. 28th, 1985, pp.16-20.

324 Sacks, O., The Autist Artist.

325 He showed severe bi-lateral temporal lobe disorder in EEG studies, as Nadia had done. Epilepsy, auditory and speech disability are associated with such disorders, although in the case of Nadia the epilepsy does not appear to have manifested itself.

and is now nationally well-known. His daily routine is just as intensive as Richard's; their present day IQ scores may be equivalent, Yamamoto having been recently tested at an IQ of 47 on the Japanese equivalent of the Stanford-Binet. What, exactly, this means is cast in doubt by Andrew, who was tested in the low 40s by one psychologist, whom he didn't like, and in the mid-90s by another, whom he liked more; the present writer tested him on Raven's Progressive Matrices, producing an IQ of 115....

With regard to emotional development, it is interesting that when Dustin Hoffman met Stephen Wiltshire he was able to say:

He is about as highly developed as any autistic person I have ever met. He has a real generous warmth about him that is very rare. And a proper smile. Most won't smile at all and those that try usually end up with a grimace.[326]

Hoffman could put an arm around Stephen without being rebuffed, which is unusual for an autistic, as well. Richard is another who possesses the ability to smile genuinely [see photo portrait in **Appendix V**], to enjoy contact with other human beings, and conveys a sunny personality to those he meets. Andrew smiles, but less convincingly, and will shake hands; he seems to enjoy working at his art in a studio full of other students. Rather than proving these are not truly autistic individuals, such sociability may indicate the therapeutic value of encouragement of their special skill.

Despite the doubts expressed earlier about the validity of some aspects of her theorising and sample, it is obvious that Lorna Selfe performed a valuable service in painstakingly examining many of the baffling aspects of the savant artist. These are summarised in table form, together with possible queries:

ORDINARY CHILD	SAVANT ARTIST
COMMENCES DRAWING 1.5/3.5 YEARS	COMMENCES DRAWING 2.5/4.0 YEARS
PRELIMINARY SCRIBBLING STAGE	NO PRELIMINARY STAGE (?)
DOODLING COMMON	NO DOODLING
CONVENTIONAL SUBJECTS	UNCONVENTIONAL SUBJECTS
FLEXIBILITY OF IMPLEMENT-USE	RIGID ADHERENCE TO ONE IMPLEMENT (?)
EVOLUTION OF DRAWING GRIP	EARLY USE OF ADULT GRIP
MODERATE PRODUCTIVITY	HIGH PRODUCTIVITY
COPYING FREQUENT	ALMOST WHOLLY DRAWN FROM MEMORY (?)
LITTLE USE OF SIGNS ETC.	FREQUENT USE OF CLOCKS, LETTERING
POOR UNDERSTANDING OF PERSPECTIVE	EARLY UNDERSTANDING OF PERSPECTIVE
FLAT, ICONIC IMAGES	ABILITY TO ROTATE 2D IMAGES IN 3D
ART PRODUCTION STOPS BY ADOLESCENCE	ART PRODUCTION CONTINUES LIFELONG
WILL DRAW/PAINT TO REQUEST	ART AS A PRIVATE PRACTICE
SELF-CONSCIOUS WHEN WATCHED	UN-SELF-CONSCIOUS WHEN WATCHED
SLOW PRODUCTION OF WORK	FAST PRODUCTION OF WORK
ART AS SECONDARY COMMUNICATION	ART AS A THING IN ITSELF
SHAPES SQUASHED TO FIT PAGE	SHAPES RUN OFF PAGE EDGES
POOR SPATIAL ORGANISATION OF PARTS	SPATIAL ORGANISATION PLANNED AHEAD

326 p. 20, Levin,A., Dustin Hoffman and the Amazing Rain Boy, 1989.

TABLE THREE: CHARACTERISTICS OF SAVANT ARTIST VS 'NORMAL' ARTIST DEVELOPMENT [ADAPTED FROM SELFE,] 1983

Summary Of Theories "Explaining" The Savant

These appear to fall into two categories, as follows:

CATEGORY ONE:

The deficits exhibited by savants compared to normals are related to the development of special skills:-

a) the lack of abstract thinking ability encourages a reliance on and
development of concrete thinking;[327] b) for those socially isolated in the family or when institutionalised, a lack or narrowing of sensory stimulation leads to intensification of motivation within specialised areas of activity due to increased attention;[328]c) reinforcement, or a compensatory development of whatever abilities remain.[329]
The main objection to the theories in Category One is that every condition said to lead to special abilities in the savant applies equally to **all** the mentally disabled, without being able to explain why a very few should benefit so spectacularly from them.

CATEGORY TWO:

The abilities of savants are compared with those of other mentally disabled persons, and attempts are made to relate these superior abilities to the development of special skills:-

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327 Scheerer, M., Rothmann, E., and Goldstein, K., A Case of "Idiot Savant": An Experimental Study of Personality Organization, **Psychological Monographs**, 58, 4, 1945.
328 Viscott, D.S., A Musical Idiot Savant: A Psychodynamic Study, and Some Speculations on the Creative Process, **Psychiatry**, 32, 1969, pp. 494-515, and Rubin, E.J., and Monaghan, S., Calendar Calculation in a Multiple-Handicapped Blind Person, **American Journal of Mental Deficiency**, 70, 1965, pp. 478-485, together with Hoffman, E., The Idiot Savant: A Case Report and a Review of Explanations, **Mental Retardation**, 9, 4, 1971, pp. 18-21, and Nurcombe, B., and Parker, N., The Idiot Savant, **Journal of the American Academy of Child Psychiatry**, 3, 1964, pp. 469-487.

329 LaFontaine, L., Divergent Abilities in the Idiot Savant, Doctoral Dissertation, Boston University School of Education, 1974, Duckett, J.M. Idiot Savants: Super specialization in mentally retarded persons, Doctoral Dissertation, University of Texas at Austin, 1976.

a) inherited abilities would have made an artist of the individual regardless, but they developed in parallel with mental disablement;[330]
b) eidetic memory enables the individual to "read off" mental imagery onto the page;[331][332]
c) a faculty for intense concentration, which may derive from impaired abstract thinking, produces exceptional ability;[333]

The main objection to the theories in Category Two is that they do not explain the savant but rather say more about the nature and development of artistic abilities themselves: inherited gifts, strong visual imagery, and the power of fierce and tireless concentration mark out all famous artists. Explanatory theories based on b) and c) see such abilities as rooted in pathology, while in the highly able artist such abilities are seen as healthy assets. Parsimony would dictate that only one root cause should produce both, i.e., artistic ability in the savant should be a healthy and valuable manifestation of everything going well in at least some neural areas, or artistic ability in both the savant and the professional artist or art student is an indication of brain pathology. With the last we are back to the "Mad Genius" conception, of course, and must find some latter-day version of Lombroso and Nordau's 19th century "degeneracy" theories in order to explain pathological talent.

It follows that **none** of the theories seeking to explain the nature of the savant have succeeded in any significant measure. It may well be that in seeking to analyse savants in terms of their special skills researchers have simply been studying what it is to be an artist or what it is to be mentally disabled, **not** what it is to be a savant. Their skills make them resemble more the talented and able than the mentally

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330 Rife, D.C., and Snyder, L.H., Studies in Human Inheritance VI: A Genetic Refutation of the Principles of "Behavioristic" Psychology, **Human Biology**, 3, 1931, pp. 547-559, Jones, H.E., Phenomenal Memorizing as a "Special Ability", **The Journal of Applied Psychology**, Vol. X, No. 3, 1926, Brill, A.A., Some peculiar manifestations of memory with special reference to lightning calculators, **The Journal of Nervous and Mental Disease**, 92, 6, December, 1940, pp. 709-726.

331 Palinopsia is a form of vivid imagery retention found in some forms of brain damage, resembling eideticism but lasting longer, or recurring at future times in a similar fashion to LSD-caused visual "flashbacks" { mentioned in Treffert, pp.133-134 }.) savant art therefore would be simply a matter of tracing around a visual image.

332 Gray, C.R., and Gummerman, K., The Enigmatic Eidetic Image: A Critical Examination of Methods, Data, and Theories, **Psychological Bulletin**, 82, 3, 1975, pp. 383-407, Siipola, E.M., and Hayden, S., Exploring Eidetic Imagery Among the Retarded, **Perceptual and Motor Skills**, 21, 1965, pp. 275-286, Roberts, A.D., Case history of a so-called idiot-savant, **Journal of Genetic Psychology**, 66, 1945, pp. 259-265, Horwitz, W.A., Kestenbaum, C., Person, E., and Jarvik, L., Identical twin-idiot savants-calendar calculators, **American Journal of Psychiatry**, 121, 1965, pp. 1075-1079, and Jaensch, E., and Menher, H., Feats of memory in a feeble-minded man, **Psychiatric Abstracts**, 1928, Part 2, 2702

333 Hill, A.L., An investigation of calendar calculating by an idiot savant, **American Journal of Psychiatry**, 132, 1975, pp. 557-560, and Rimland, B., Savant capabilities of autistic children and their cognitive implications, G. Serban, editor, **Cognitive Defects in the Development of Mental Illness**, Brunner/Mazell, 1978.)

disabled-it is the skill itself which dominates all exceptional individuals, with or without disability.

Despite the apparent failure of older theories such as those listed above, researchers continue to speculate on the nature of savant talents. Perhaps exceptional abilities, as White (1988) speculates,[334] depend on the same underlying type of structure. Perhaps spatial ability is that foundation, in its differing manifestations as rotational, relational, orienting, holistic ability. However, White's thesis goes in another direction: he speculates that savants may organise large portions of long-term memory in the service of their unusual talents, probably sacrificing linguistic neural space for the elaborated representation of their abilities. However, as has already been said, normal or very intelligent individuals with equal or greater artistic ability do not seem to demonstrate a significantly lower linguistic ability, thus suggesting no re-allocation of neural capacity.[335] Memory abilities by themselves are insufficient to explain savant talents, and in particular artistic ability. Goldsmith and Feldman (1988) would agree that gifted prodigies and savants should be considered together as similarly puzzling phenomena. However, they believe that other, more general factors contribute to the savant:

1) overall lack of flexibility in thinking or direction of attention;

2) a lack of ability to know what is or is not important to remember;

3) an intimate and essential relationship between savant and an ability which provides pleasure, strength, and a sense of belonging.

All of this is clearly true; but, equally, the same things expressed in different, more positive terms apply to artists who are dedicated to their disciplines, can think of little else, pay attention to almost everything in their optic array, and derive from their art their raison d'être.

Goldsmith and Feldman say that it may be that adopting a more social and sociable orientation to the world makes the exercise of savant skills less necessary, citing Nadia and her apparent loss of interest in art production with increased language skills. Richard, however, is a very socially oriented savant, whose need for his special talent is even stronger now than before. Indeed, a very good case could be made for identifying the special talent as the one channel through which the savant may be able to gain a social role and value which is often difficult or impossible to attain for the learning disabled. Andrew attends art classes with his mother and

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334 p.13, White, P.A., The Structured Representation of Information in Long-Term Memory: A Possible Explanation for the accomplishments of "Idiots Savants", **New Ideas in Psychology**, Vol.6, No.1, 1988, pp.3-14.

335 p.17, Goldsmith, L.T., and Feldman, D.H., Idiots Savants-Thinking about Remembering: a response to White, **New Ideas in Psychology**, Vol.6, No.1, 1988, pp.15-23.

appears to have improved both socially and artistically as a result, while Stephen has already been described as improving through emphasis on his art.

Drs Hermelin and O'Connor have for some years conducted research with savants, as a furthering of their long-standing interest in autism in children. They say that the efficient use of domain-specific motor programmes by artistic savants may indicate the importance of cerebellar and/or motor cortex structures.[336] In autistic savants however, recent research by Courchesne[337] seems to indicate that hypoplasia of vermal lobules VI and VII of the cerebellum, immaturity or lack of development of those parts, is at the root of autism. Motor imitation impairment has been a consistent characteristic of autistic children, causing failure to imitate the actions and facial expressions of others, one of the earliest and most important forms of social interaction. Autistic individuals are marked out from normals and from the mentally handicapped by their inability to comprehend affective expressions and impoverishment of expression of affect, as well.[338] If there is a "modular system" of sub-cortical and cortical structures leading from the brain stem, to the language centres of the left hemisphere, through to the affective control areas of the left frontal lobe (which suffer immature development in the autistic individual during both foetal and infant stages) then the sort of elaborate motor skills/stored "schemata" needed by the artist would seem an unlikely acquisition for such a person. Autistic savant artists would, therefore, seem impossible, and yet they exist. This is, of course, assuming an "all-or-nothing" scenario, where the cerebellum is rendered generally immature. A possible alternative is that where hypotrophy exists, a compensatory hypertrophy may coexist... By following such an hypothesis we may consider the only theory which seems to offer any sort of hope in clarifying the many paradoxes of the savant-Treffert, too, has shown enthusiasm for this theory-it is that of Geschwind and Galaburda, "The Pathology of Superiority", the sort of theory which could explain the co-existence of ability and disability in the savant; it fits well into the cognitive modular model of intelligence, and produces some explanation for the curious associations of apparently unrelated physical characteristics noticeable in savants.

Arthur Holstein said in 1965 that "...the importance of the Idiot-Savant lies in our inability to explain him..."[339] Our inability to explain him or her may not lie in any lack of knowledge on our part, although it may, but rather in the fact that there is no

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336 Hermelin, B., and O'Connor, N., Spatial Representations in Mathematically and in Artistically Gifted Children, **British Journal of Educational Psychology**, 56, 150-157, 1986.
337 Courchesne, E., Neuroanatomical systems involved in infantile autism: The implications of cerebellar abnormalities, in G. Dawson, editor, **Autism: New Perspectives on diagnosis, nature, and treatment**, New York, Guilford Press, 1988/9.
338 pp. 454/455, Dawson, G., Cerebral Lateralization in Autism: Clues to Its Role in Language and Affective Development, in pp. 437-461 of D.L. Molfese and S. J. Segalowitz, editors, **Brain Lateralization in Children: Developmental Implications**, New York/London, The Guilford Press, 1988.
339 quoted p.22, Goldsmith and Feldman.

such category as the savant, that such individuals must be considered as a variant not of the mentally disabled but of the talented and exceptional. What is required is a shift in mental perspective rather similar to that in which such "savants" are so particularly skilled, and in which we ought not to show ourselves their inferiors.

Savants And Autism:

James Henry Pullen, "The Genius of Earlswood", (1835-1916) the retarded artist and builder of elaborately detailed ship models, could speak only in telegraphese, syntactically unconnected one or two word clusters, in a similar manner to that of Richard.[340] Post-mortem examination of his brain showed underdevelopment of the left hemisphere, together with poor depth and complexity of cortical convolutions in the speech areas.[341] Most of the other idiot savant artists have similar speech disabilities. Pullen's corpus callosum was very large, while, even allowing for the probable shrinkage of other areas of his brain due to senile dementia, by comparison the occipital areas were normal or larger than normal. Sano, the doctor who carried out the post-mortem examination of Pullen's brain, stated that : "...he was bound to have special capacity in the visual sphere of his mental existence."[342] It is interesting that Pullen's brother exhibited a similar pattern of deficits and talents.

However, the only other autopsy carried out on an idiot savant and reported in detail was presented by Steinkopff in 1973, and revealed very little similarity to Pullen. This individual was skilled in mathematics, music, and calendar calculation[343] No gross abnormalities were observed under macroscopic examination, brain size was normal, with no observable pathologies; however, under the microscope neuronal loss was evident in the third and particularly in the fifth cortical layers, especially in the temporal lobe including Broca's area. All areas showed shrunken neurones, while the loss of Purkinje cells in the cerebellum was particularly evident. Such brain damage is sometimes evidence of perinatal or post-natal hypoxic changes. It could as well be evidence of any other form of atrophy

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[340] Richard is left-handed, as is his normal brother; similarly a photograph in the report would seem to suggest that Pullen was left-handed.

[341] p.267, Sano, F., James Henry Pullen, the Genius of Earlswood, pp.251-267, **The Journal of Mental Science**, No. 266, Vol.64, July, 1918.

[342] **Ibid.**

[343] Richard can date with accuracy all his works as quickly as they are presented to him, over a span of thirty years, and say both his age at the time of their production, together with the interval in years from then to the present day. He is able to perform similarly with each edition of his prized collection of ***The National Geographical Magazine***-quite an achievement for someone supposedly possessed of an IQ of 30! However, he either cannot or will not attempt 2+2, making a nonsensical response and waving his hands about when asked to do so. He is able to tell the questioner the major cities of most countries in an atlas, pointing to them, although he seems not be able to read in the usual way. He may have memorised his father's verbal instruction and connected the word-sounds with the shapes of the city names.

leading to impaired cognitive performance. Clearly, damage of this sort cannot be causal for savancy, or all such unfortunates would be savants.[344] The two reports contain no striking resemblances of feature. Pullen died at 81 and the other savant at 55; Lewis Hill[345] has claimed that the presence of advanced arteriosclerosis in Pullen confounds any attempt to relate brain abnormalities to his mechanical and drawing skills. It seems significant, however, that the very abnormalities regarded both then and now as more likely to be found in the brains of individuals skilled in the way Pullen was skilled were found in the savant on post-mortem. A Magnetic Resonance Imaging scan was carried out on Richard, with inconclusive results (see reproduced scan views in **Appendix IV**): the brain seems within normal bounds, although there is evidence of some atrophy, while the corpus callosum appeared no larger or smaller than in anyone else. What differences there are must be at cellular level or below, and may contribute to the atrophy, which could be evidence of poor development overall, leading to autism.
In the first three months of her pregnancy, Richard's mother suffered a bout of illness resembling glandular fever, possibly an atopic disorder triggered by exposure to loft dust and detritus. This may have reduced blood flow and oxygen to Richard's brain at a crucial period in his foetal growth.

Brain scans[346] appear to suggest that recurrent utterances occur in patients who have both left cortical and basal ganglia damage, with the further conclusion that the smallest lesion required to cause a recurrent utterance (a favourite of Richard's is "Home and Away!") is an anterior lesion including the basal ganglia. Tourette's syndrome and Parkinson's disease both involve basal ganglia damage and recurrent utterances.

Richard is a diabetic, and one may speculate just how much brain damage this disorder is causing over time, particularly considering his more frequent "crises" and a certain increasing lack of certainty in movement, which may be traced to some sort of basal ganglia damage, as well, although none of this showed on his MRI scans. Recent work in the Department of Psychology at the University of Edinburgh on the effects of bouts of hypoglycaemia on diabetic cognitive function seems to indicate a steady worsening of ability as such episodes continually occur, especially in Wechsler right hemisphere Performance IQ measures.[347] It is noticeable that some of Richard's most recent art work is less convincing than before, a variety of "tiredness" becoming apparent. This **may** be explained by a gradual loss of visual-

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[344] cited in Lewis Hill, A., Savants: Mentally Retarded Individuals with Special Skills, pp.277-298, **International Review of Research in Mental Retardation**, Ellis, N.R. {ed.}, Vol. 9, Academic Press, N.Y., San Francisco, London, 1978.

[345] p.286, **Ibid**.

[346] Brunner, R.J., Kornhuber, H.H., Seemuller, E., Sugar, G., and Wallesch, C-W., Basal ganglia participation in language pathology, **Brain and Language**, 16, pp.281-299, 1982.

[347] Langan, S.J., Deary, I.J., Hepburn, D.A., and Frier, B.M., Cumulative cognitive impairment following recurrent severe hypoglycaemia in adult patients with insulin-treated diabetes mellitus, **Diabetologia**, 34, 337-344, 1991.

spatial ability brought about by the cumulative effects of hypoglycaemic episodes. Nevertheless, most recently Richard has had to undergo open-heart surgery to repair a large interventricular hole discovered to have been present from childhood. At the time of writing, Richard is recovering strongly.

With application to the case of Richard, EEG studies have found that the untrained subject shows greater activity in the right hemisphere while whistling,[348] and when processing music generally.[349] Several studies have suggested that trained musicians adopt an analytic approach to their work which involves the left hemisphere rather more.[350] Richard is extremely enthusiastic about both classical and popular music, often drawing while wearing his "Walkman", or while listening to symphonic or organ music on the stereo system. He is able to name the compositions, their composers, and other details such as the key in which they were composed. As recreation away from his drawing "work", he dances rhythmically to popular music, either in his room or by the drawing board, something which produces in him a state of high excitement. Stephen Wiltshire, too, dances to music on his favourite TV programme, Top *of the Pops*, singing and using gestures memorised from those of the performers.[351] Richard has been given some bongo drums, which he beats with a fine sense of rhythm and timing. Curiously, Touretters are well-known to make good drummers, too.

Stephen, Andrew, Neil, and Richard possess the flat, expressionless quality of voice which is associated with autism. Such aprosodic speech might seem to argue against a reliance on the right hemisphere, the hemisphere long identified as the home of affective quality of speech. However, damage to the homologous area of the right hemisphere to that of Broca in the left, in the anterior-parietal supra-Sylvian region, with some damage to the basal ganglia, may well produce exactly the autistic "voice" while leaving untouched the ability to feel emotion, and probably by extension, music. Broca's aphasia disrupts syntax in ways very similar to that heard in the autistic; it might be possible to speculate that autistic speech dysfunction is due to bi-lateral lesions in homologous areas of the right and left hemispheres. David Bear, cited in Lucci, Fein, et al (1988), has suggested that in some brain areas and with some psychological functions, epileptic discharge may result in *hyperfunction* rather than disrupted function there; the same authors note that Milner and others have found strong evidence that the right temporal region in right handed males is necessary for tonal memory and timbre discrimination. Paul, the autistic musical savant Lucci and Fein et al describe, is highly skilled on percussion as well as piano, but is also able in visual art; suggestively, his Rey-Osterrieth figures and block test

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348 p.93, **Ibid**.

349 Hirshkowitz, M., Earle, J., and Paley, B., EEG alpha asymmetry in musicians and nonmusicians: a study of hemispheric specialization, **Neuropsychologia**, 16, 1978, pp.125-128.

350 Code, C., **Language, Aphasia, and the Right Hemisphere**, John Wiley & Sons, UK., 1987, p.92.

351 Levin, A., Dustin Hoffman and the Amazing Rain Boy, **The Mail on Sunday "You" Magazine**, May 21, 1989.

reproductions were always started and were more complete on the left side, indicating greater reliance and perhaps stronger functioning of the right hemisphere.[352] As has been mentioned, both Jose and Nadia Chomyn in EEG scans showed bi-lateral abnormalities of just that sort described above, abnormal discharges being found in the Sylvian regions of both hemispheres.[353] EEG studies of other savants should be carried out to verify or disprove this speculation.

Autistic children exhibit abnormalities of vestibular function, such as diminished postrotatory nystagmus.[354] They have an increased tolerance to spinning and twirling, often enjoying doing so; spinning around on one spot and a fascination with spinning objects, such a spun coins, was a characteristic of Richard when young. It is possible that the primary dysfunction responsible for such behaviour might centre in the basal ganglia and in the frontal lobes of the cerebral cortex: animal studies mentioned by Damasio and Maurer indicate that damage there could serve to cause disregard of labyrinthine stimulation. There appears to be a preference in most autistic children for somatosensory stimuli over visual or auditory stimuli.[355]

Courchesne *et al* [356] in a NMRI study of a 21 year-old autistic male revealed that underdevelopment of the cerebellum in some lobular areas could explain the lowered abilities of autistic individuals such as Richard in speech, learning, attention, and possibly emotions, as well. However, in the present research, the MRI scan of Richard revealed no significant immaturity of any cerebella lobule, casting doubt on the generalisability of the findings of Courchesne *et al* .

Ritvo *et al* [357] conducted autopsies which produced findings consistent with those of Courchesne, in that four subjects ranging in age from 10 to 22 years had a smaller number of Purkinje cells in their cerebella than had non-autistic individuals. These large cells are responsible for releasing inhibitory neurotransmitters which may serve to "damp down" the level of incoming sensation. Poorly regulated sensory inflow, a flood of sensation, is often thought to occur in autism, accounting for the inability which many autistic individuals appear to display in dealing with the

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352 Lucci, D., Fein, D., Holevas, A., and Kaplan, E., Paul: A Musically Gifted Autistic Boy, Chapter 17 in L.K. Obler and D. Fein, **The Exceptional Brain: Neuropsychology of Talent and Special Abilities**, N.Y./ London: The Guildford Press, 1988.

353 Sacks, O., The Autist Artist, p.18, and Selfe, L., **Nadia**, pp.114-115.

354 **Ibid**.

355 Damasio, A.R., and Maurer, R.G., A Neurological Model for Childhood Autism, **Archives of Neurology**, Vol.35, Dec. pp.777-786, 1978.

356 Courchesne, E., Yeung-Courchesne, R., Hesselink, J.R., and Jernigan, T.L., Abnormal Neuroanatomy in a Non-retarded Person with Autism, **Archives of Neurology**, Vol.44, March, pp. 335-341, 1987.

357 Ritvo, E.R., Freeman, B.J., Scheibel, A.B., Taihung Duong, Robinson, H., Guthrie, D., and Ritvo, A., Lower Purkinje Cell Counts in the Cerebella of Four Autistic Subjects: Initial Findings of the UCLA-NSAC Autopsy Research Report, **American Journal of Psychiatry**, 143:7, July, pp.862-866, 1986.

apparently chaotic and overwhelming outside world. Steinkopff's autopsy of the savant in 1973 showed exactly this deficiency, indicating his probable autism (see section on "inhibited" blue-eyed children; with regard to such characteristics, it may be possible to place light-eyed autistics at the furthest end of a behavioural spectrum where such relatively normal children are positioned less extremely).

In an interview, Dr. Courchesne amplified on his work, saying that the abnormality occurs early in brain development, either during early foetal development or towards the end of the first year or during the second year of life. If such early dysfunction leaves the autistic individual abnormally subject to stimulation, the tendency to stare at blinking lights or spinning wheels may be a coping mechanism, such rhythmical experiences having a calming effect on the cerebral cortex.[358]

Clearly, it is difficult to judge such matters until autopsies are possible; the gross physical morphology of cerebellar structures varies considerably in the normal population, leaving possible pathological immaturity a judgement fraught with ambiguity. It may be, as well, that reduced numbers of Purkinje cells, or pyramidal cells not reaching their allotted cortical layers, shows an overall immaturity in the autistic and autistic savant brain.

Savants And Asperger's Syndrome

Treffert includes a section which briefly considers the condition described in 1944 by the Austrian psychiatrist, Hans Asperger, and the number of individuals diagnosed as suffering from Asperger's Syndrome who may be called savants.[359] As Treffert says, the best review of the syndrome is Dr. Lorna Wing's 1981 article, where she considers Asperger's original cases and adds 34 of her own; from these case studies emerges a composite picture of such people:

1) There is a 6:1 male/female ratio;

2) There is delayed speech; when present it is often repetitive, with monotonous intonation, and lack of use of first person pronouns;

3) Facial expression is sparse, with little non-verbal communication: eye contact is avoided and others are often "stared through" rather than engaged;

4) Social interactions are restricted, naive, and odd;

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358 Schmeck, H.M., Brain Abnormalities Cited As Factors in Autism, **Science Times-The New York Times**, Tuesday, June 7th, 1988, pp.19-21.

359 Asperger, H., Die "autischen Psychopathen" im Kindesalter, **Archiv fur Psychiatrie und Nervenkrankheiten**, 117, 1944, pp. 76-136.

5) Preferred activities are usually repetitive, and carried out exhaustively; change is resisted, together with strong attachment to particular possessions;

6) Asperger's sufferers are usually clumsy, with peculiar posture and gait-motor co-ordination in general is poor;

7) Memory is often superb, with narrow interests mastered to a high level;

8) Learning in areas other than those of the special interests is frequently poor;

9) Language is generally of a limited sort except within the areas of special interest, where it becomes expansive, pedantic, with an extensive vocabulary, but lacking in understanding of the words used; when expounding, they tend to adhere to set "lectures".[360]

Where Asperger's Syndrome sufferers differ from those with Early Infantile Autism is pointed out by Treffert:

1) autistic individuals are not particularly clumsy or have poor motor co-ordination (One could dispute this-on the other hand, some autistics display beautiful dancing co-ordination);

2) autistic individuals do not possess the comparatively high level of social functioning of Asperger's cases;

3) autistic individuals are often mute or have globally impaired speech, whereas, within certain limits, the Asperger's Syndrome person can expound with superficial authority for as long as they have an audience;

4) most autistics have a low IQ, while the Asperger's Syndrome individual usually possesses intelligence which is normal, or sometimes above normal.[361]

It is possible that such individuals fall within the category of high-functioning autism, where Early Infantile Autism has been overcome with age, development, and adaptation and adjustment to social demands. Very recently, it has been speculated that eccentric professors, train spotters, collectors of trivia, "walking encyclopaedias" may be suffering from Asperger's Syndrome: someone who knows everything there is to know about 50 types of carrot, or someone who learns the door colours of all magistrates' courts in his area, or a boy who daily re-enacts Rommel's major W.W.II tank battles, all suffer from Asperger's Syndrome, says Dr.

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360 Wing, L., Asperger's Syndrome: a clinical account, **Psychological Medicine,** 11, pp. 115-129, 1981.

361 Treffert, **Extraordinary People**, p. 211.

Uta Frith, of the Medical Research Council's cognitive development unit in London:

> The detachment which aids their academic work may lead to problems in everyday social relationships. As children, often unrecognised in ordinary schools, they may suffer from merciless teasing and bullying. As adults their social naiveté may bring them into conflict with the law.[362]

It is interesting to note a strong similarity between the above descriptions and the way in which psychopaths, who compulsively act-out murderous fantasies, have been described: in the psychopath there may be chronic underarousal of the left hemisphere controls speculated about by Tucker.[363] Psychopaths appear to have some characteristics which identify them, writes Brian Masters (1991): the compulsion to take photographs, especially of victims of their violence, withdrawal, introspection, solitary pleasures, shyness, severe isolation, and the inability to communicate without fear of humiliation. Hypochondria is another typical characteristic of the psychopath, possibly being latently homosexual, having had little sexual experience, being emotionally impoverished, a poor judge of others' motives, and as a consequence, distrustful of everyone. Usually under 35, and male, he is narcissistic, vain, intelligent, and pedantic.[364] Erich Fromm, when writing about the nature and characteristics of a "necrophile" (an interchangeable type with the psychopath), listed some additions to this list: he may have the habit of breaking match sticks, produce featureless, lifeless conversation, have a pale face, a preference for monochrome or black-and-white rather than colour, and especially a fascination for mechanical things. Above all, "necrophiles" have a rich, overblown fantasy life, secret and all-absorbing for them. When fantasy breaks through into reality, that is when the crimes are committed, in a state of overwhelming compulsion.[365]

Violent Asperger's Syndrome individuals have been reported: Mawson *et al* (1985) described a male of 44 who, as a boy, had attempted to strangle a girl, stabbed another, attempted several attacks on girls, once on a dog, and once on a baby in a supermarket; he has a preoccupation with witchcraft and cutting up babies, and has frequent violent thoughts concerning actresses. He has an IQ of 133, an obsession with mechanical and scientific things, particularly organic chemistry, and has the "outlook of a research worker in pure science". He speaks during inhalation, lacks intonation, and has a largely immobile facial expression, although he has certain tics and mannerisms, too. Clumsy, socially awkward, isolated, having a dislike of alteration to his daily routine, totally without embarrassment at social miscues, he was used by the authors to claim that there was a closer association of violence and Asperger's Syndrome than was usually thought. Injuries to others caused by careless use of chemicals, threats to stab a mother, and one case of an attack on a fellow

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362 Frith, U., quoted by O'Sullivan, J., Train spotters "may suffer from autism", **Independent**, 14/9/91.
363 Tucker, p. 18.
364 Masters, B., What makes a monster, **The Sunday Telegraph**, 28/7/91.
365 Fromm. E., **The Anatomy of Human Destructiveness**, London: Penguin, 1973.

psychiatric patient are found in the literature, together with evidence of extreme egotism, and callousness toward others.[366] It is clear from all the above that the diagnostic categories found in the DSM-III and in the pages of noted authorities on the various syndromes and pathologies are pathetically permeable; in practice, few workers with the learning disabled or the mentally disordered apply such "labels" to their people.

Richard And His Art

Richard is one of the artistic savant subjects of the present speaker; at an earlier time, cognitive tests conducted with him by the Educational Psychologist, Lorna Selfe, showed the following results [**TABLE FOUR**]:

STANDARDISED TESTS		
RICHARD WAWRO (born 14/4/52)		
BRITISH ABILITIES SCALE		
(at age 17.5)	**ABILITY**	**PERCENTILE**
SPEED		
speed of information processing	34	<1
REASONING		
Matrices	48	<1
Similarities	26	<1
SPATIAL IMAGERY		
Block design (Level)	90	13
Block design (Power)	67	12
Rotation of letter-like forms	<10	<1
Visualisation of cubes	<30	<1
SHORT-TERM MEMORY:		
Immediate visual recall	43	7
Delayed visual recall	47	54
Recall of designs	49	4
Recall of digits	101	<1
RETRIEVAL AND APPLICATION OF KNOWLEDGE		

366 Mawson, D., Grounds, A., and Tantam, D., Violence and Asperger's Syndrome: A Case Study, **British Journal of Psychiatry**, 147, 566-569, 1985.

Basic arithmetic	{Attempted}	<1
Work definitions	{ but}	<1
Word reading	{abandoned}:	<1

I.T.P.A. Visual memory Raw score = 8 (4 symbols)
Benton Test-Average category
Eidetic memory-very good

TABLE FOUR: PSYCHOMETRIC TESTING OF RICHARD WAWRO (adapted from Selfe, 1983)

It seems, therefore, using these tests as extremely general indicators of Richard's abilities, that:

1) He falls in the lowest 2% of intelligence

2) High points of his tests were in Spatial Images and Block Design

3) He showed skill in recall of designs and recall of abstract visual information

4) He was well below average in retrieval and application of knowledge

5) He had good "eidetic" ability.

As has been said, it is debatable how much trust can be placed in the above figures, considering the unavoidable problems encountered in using psychometric measures with the retarded. Difficulties encountered are apparent in the record of some of the subtests carried out.

It has been a tediously reiterated dictum of researchers that savants, wonder calculators or artistic prodigies, burn out, collapse, or somehow self-destruct. No adequate reason is ever given to support this belief. Richard is an example of how a classic idiot savant may, through intense effort and very high rate of production, self-improve, not self-destruct, and, without tuition, reach a level of skill which most ordinary artists might envy. An exhibition of 75 of his works in the Department of Psychology of Edinburgh University in October and November, 1988, arranged by the present writer, demonstrated through a pictorial chronology how he has developed as an artist.

Richard was born on the 14th of April, 1952, in Tayport, Fife; as stated, his mother's pregnancy was marred by what was thought to have been glandular fever, a probable cause of his later problems. He lived in Fife with his Polish father, Edward, and Scottish mother, Olive, until 1960, when all removed to Edinburgh. At three weeks old, he was diagnosed as having cataracts in both eyes. Four needling operations intended to stir the cataract material to allow some light to get through to the optic nerves followed. Since then Richard's eyesight has always been poor, severely myopic. Diagnosed at three as mentally deficient, supposedly with an IQ of 30, he

developed lymphosarcoma at five years, which he survived after massive radiotherapy. As an infant, he would sleep barely three hours a day, yelling, screaming, jerking ceaselessly.
Richard would time and again crawl to the piano and, unbearably for everyone else in the household, he would strike the same note for hours. Later, as a boy, he would stand apart from the other children, fascinated by the play of light on a shiny mobile. He was always spinning balls, coins, pencils, bottles, even himself, staring at the effects of sunlight on polished pots and pans. His artwork continues in this Turneresque delight in the effects of light, colour and the sun.[367] Richard, when reminded of his old obsessions, is upset and refuses to listen-"All finished, all gone," he states, very firmly.

At 18 he was found to be suffering from diabetes, while at 26 it became necessary to have all his teeth removed. Early tests revealed that he has high note deafness. One family-produced leaflet states that he did not speak aloud until the age of eleven years, while another source maintains that he uttered the word "Mum" at 4/5 years.

Richard has attended special schools and day centres all his life, but has never learned to read or write. He has recently discovered how to sign his works, although it is not known if he understands what "Richard Wawro" refers to or symbolises. He draws his inspiration from television, travel books, he and his family's own world travels, and even converts sounds and music from radio and records into visual analogues. Apart from the popular and classical music already mentioned, another source of auditory stimuli are the BBC sound effects records he possesses.

His work is primarily realistic, the colours of his preferred medium, oil crayon, layered and blended into sometimes almost photographic representations of snow scenes or tropical sunsets which display great skill in suggesting Arctic chill or sweltering heat. He does not copy, rather he sits at his table with a piece of card and his crayons, nose three inches from the surface, drawing with immense perseverance until the images in his mind have been transferred to the white sheet. Images stored in his memory for months or years may, unpredictably, take shape under the edges of his unsharpened crayons. His observation of distant objects aided by an ever-present pair of binoculars, he is precise in his detail, accurate in his use of perspective, and attains a smoothly textured finish. Only people escape his skill, something which might be expected if one recalls his autism. The autistic lack social ability-indeed, it may even be that they do not see a face as a face but rather as a collection of features without relation or meaning for emotional, personality or social interpretation.

Richard has had over 100 exhibitions all over the world, selling his work steadily since the first at the DeMarco Gallery on 14th January, 1970. In 1981, ABC-TV's

[367] Picasso, too, would turn his black eyes to the sun and claim that he could stare straight into it; this would seem to be more a demonstration of machismo than of autistic leanings, however.

programme, "*That's Incredible*" had him as its subject, while "*With Eyes Wide Open*" was a prize-winning video which explored the nature of his gifts. The exhibition at the Department of Psychology, Edinburgh University, was the first to trace the course of his artistic development over the years, showing the recurrence of some images from his childhood work in later pieces, the greater and greater accuracy of his use of colour, its growing subtlety, and the progressive loss of crude boundary lines in his forms. In every other way than in his art, Richard remains severely handicapped, totally unable to survive on his own in human society. However, his confidence in his artistic ability, constantly reinforced over the years by a tremendously supportive family, has enabled him to make a bridge from his autistic confusion to the real world. Perhaps the best way for him to make sense of our world is by ordering and restructuring it with his wax crayons on white card, by his skill gaining at least an appearance of mastery over the solid and material while the social world of humans possibly remains a mystery. The joy he expresses on the completion of each piece may be that of someone celebrating the attainment of one more fragment of power over reality.

However, doubt has been cast on Richard's ignorance of the social world. Laurence Becker made a study of Richard, while actively promoting him and his art work in America[368], in which he noted that a picture titled by Richard's father *The Gilbert Islands* had originally been entitled by Richard (taped at a "titling session") *International Festival Soup in the Gilbert Islands*, while *Watching Portable Television in Morocco* was a shortened version of Richard's original *Arabs Watching Portable West German Colour TV of Surfing in California*. Becker believes these full titles display some sort of social commentary, if not gentle irony or humour. In *Free Range Hens* there is a giant golden egg with "'78" painted on it rising over the hen yard like an enormous moon, in *Life on Earth* a group of monkeys is shown playing high up in the tree tops, while in *White Monkeys at USA Zoo* another group of monkeys play like children in a sand pile against a background of a garage with a large American flag painted on the side. *Cash and Carry in Nairobi* and *Watching the Trains Go By in Western Australia* seem to suggest to Becker an attempt to show the impact of modern civilisation on traditional cultures.[369] The present writer would indicate as well the basic concept behind Surrealism, where new effects are achieved by the juxtaposition of disparate objects or events, the sewing machine and the umbrella meeting on the operating table. Such concordia discors produce both shock and humour. But how can wit flourish in the desert of mental disability? Perhaps in the same way that art does. Sadly, however, it seems much more likely that Becker is crediting Richard with far too much sophistication of thought. Richard is an enigma, whom wishful thinking

368 Becker, L.A., Designing Environments for Optimum Growth: Meeting the Needs of Learners with Special Gifts, a project demonstrating excellence submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, January 1980, Union Graduate School, The Union for Experimenting Colleges and Universities.
369 p.36, **Ibid.**

can all too easily turn into a mirror in which anyone may run the risk of seeing only their own imaginings.

Becker clearly draws entirely the wrong conclusion concerning the apparent lack of guns and acts of violence in Richard's work.[370] Recounting a series of anecdotes about Richard using his art as an outlet for frustration and violent feelings within him, Becker apparently agrees with an observer that his work is non-violent. It seems Becker did not look at Richard's earlier work very closely. Like most boys, he thoroughly enjoyed drawing guns, fighting soldiers, planes, aircraft carriers, tanks, and big explosions. Later influences, perhaps those of a very Catholic household, may have turned him toward more peaceful subjects. Indeed, when one piece showing war vehicles in Cambodia is shown, his father is careful to explain that Richard merely wanted to draw attention to the terrible events occurring there at the time, not to glory in the trappings of mechanised conflict. Richard is quick to agree, and vehement in his condemnation of war, but a suspicion remains that some less pure motivation has not completely been eradicated.

One piece of artwork produces very strong personal reactions in Richard. His indignation over a fire at ***Thin's*** book shop some years ago, which his father had believed derived from condemnation of the hooligans who committed arson on Richard's favourite shop, may in fact have its source in anger over the stealing of his mother's handbag in Waverley Market at about the same time. Possibly he is aware that this is a work, ostensibly about the book shop fire, over which it is permissible to express violent emotion, the exact cause of which may vary.

Richard appears to have, in addition to an island of artistic talent, another eyot or two of ability, up thrust from a sea of deficit. These other two talents enable him to have a truly formidable knowledge and awareness of geographical distances and contiguities, together with a sense of delight in incongruous juxtapositions; all three islands may derive from the bedrock of a hyper developed sense of **relationship**, a spatial talent as far beyond that of the normal individual as **it** is beyond all the rest of Richard's verbal and reasoning skills put together. Perhaps the secret of the savant is precisely this possession of such an acute sense of where everything is, where they are in relation to everything around them, and how material objects relate to each other from any direction.

Summary

For the savant, the application of a sense of **place** is immediate and obvious. For the calculator, there may be a mental landscape where the relationships of numbers are sensed in much the same way that we sense where we normally keep our slippers, or where the bread is, or where our favourite book is shelved, half-consciously. As

370 p.38, **Ibid**.

we know the streets of the neighbourhood where we were brought up, so we know the short-cuts and the ways in which a friend's house may back onto ours and be reached across the garden fence, rather than by going the long way round. Numbers are the lightning calculator's friends, and exist in a limitless network of probably three-dimensional pathways. For the musical savant, melody and structure are sensed but not consciously, rationally analysed; the relationships in musical structure are felt and enjoyed emotionally, and may be moved among just as the artist may move among the structures of the real world, and the calendar calculator moves among the geography of numbers, always aware of where he or she is, and equally aware of the location of every object, number, or melody in relation to them and to each other. However, they appear to have no self-consciousness of how they do all these things.

Both space and time connect everything kept in the savant memory, so that everything can be timed and dated with unthinking accuracy. It is possible that savant skills may have evolved in some individuals simply to try to impose a variety of order on the apparently chaotic and senseless Universe in which they found themselves; such skills may therefore be regarded as coping mechanisms in the fortunate few able, and encouraged, to develop them. In trying to impose such a framework of order on their bewildering sensations, savants demonstrate the deep-rooted impulse which rules everyone from the time we are born. Their tragedy is that in most people this results in rational thought, science, culture, and society, while, for the savant, Forster's "Only connect" produces arid landscapes through which they wander like the Tarot's Wise Fool, innocent, joyful, but blind. (Oliver Sacks' conception of savant thought processes in "The Twins" contributed largely to the above speculation.)

It is curious how those left-brained intellectuals who dominate in our culture pay lip service to the greatness of past artists such as Michelangelo, Van Gogh, and Picasso, but are constitutionally incapable of appreciating what it was which drove them to that greatness. Rimland has pointed out how savants resemble the greatest creative geniuses in their single-minded intensity, obsessiveness, and ritualisation-they are self-absorbed, compulsive, often isolated and idiosyncratic individuals. Within them burns an emotional force which drives them on to the conclusion of their work: Michelangelo, Van Gogh, and Picasso, their common denominator is emotion, harnessed and directed. Despite the description of autistics as unemotional, unable to recognise emotion in the faces of others, anyone who has worked with them will be able to testify to the violence of the emotions they bear within them. It may be that artistic savants have simply found that road down which self-expression is allowable. Where self-expression exists, so, too, does personal growth: the praise which Stephen, or Richard, or Andrew, or any of the others receives for their artistic efforts provokes such visible and obvious pleasure that no-one could possibly wish to see such an avenue to greater interaction with and adjustment to the world of others closed off through neglect or ignorance.

Efforts to encourage other areas of social skills to develop without reference to their artistic expressions must be self-defeating and even counter-productive; clearly, the open emotional conduit must be broadened, allowing feeling to flow even more freely, and the emotional river must be allowed to carry with it, like leaves on a rising tide, the other abilities we all take so much for granted.

MODULAR THEORIES OF PSYCHONEURAL ORGANISATION

It does not seem possible to explain the existence of the savant or the dyslexic without involving modular theory. Indeed, it may not be possible to explain normal psychoneural functioning without modular theory. Ellis and Young (1988) describe modularity as follows:

It assumes that there are large numbers of semi-independent cognitive processes or systems, each capable of separate impairment, which together perform the work necessary for complete and healthy mental life. One set is responsible for face recognition, one set responsible for word recognition, another for maintaining our orientation in the geographical environment, another for producing speech, and so on. Every module engages in its own form of processing **independently** of the activity in modules other than those with which it is in direct communication. Given the concept of **isomorphism**, modules are distinct within the brain, as well, so that brain injury can affect the operation of **one** or **some** modules while, at the same time, leaving the operation of other modules intact. This theory allows **face recognition** to be intact in a patient who has suffered some brain insult through injury, illness, or birth trauma, while at the same time she may have great difficulty **reading**.[371]
Marr (1976)[372] and Fodor (1983)[373] have been the most influential writers in this area in modern times, following in the footsteps of Simon[374] Marr suggested that

[371] Ellis, A., and Young, A., **Human Cognitive Neuropsychology**, p.10, Erlbaum, 1988.

[372] Marr, D., Early processing of visual information, **Philosophical Transactions of the Royal Society {London}**, B275, pp. 483-524, 1976.
[373] Fodor, J., **The modularity of mind**, Cambridge, Mass.: MIT Press, 1983.
[374] Simon, H.A., The architecture of cognition, **Procedures of the American Philosophical Society**, 106, pp. 467-482, 1962..

complex systems such as the mind and the brain are very likely to evolve toward a modular organisation in the course of their development; Marr said:

> If a process is not designed in this way (split up and implemented as a collection of small sub-parts that are as nearly independent of one another as the overall task allows), a small change in one place will have consequences in many other places. This means that the process as a whole becomes extremely difficult to debug or to improve, whether by a human designer or in the course of natural evolution, because a small change to improve one part has to be accompanied by many simultaneous compensating changes elsewhere.[375]

Let us consider modularity using Ellis and Young's analogy of hi-fi stacking systems: in these, record decks, cassette decks, radio tuners, amplifiers, speakers, headphones and all the rest combine to form the complete system. Damage to one of these can be detected, and that isolated module removed and replaced. A record may sound dreadful, and the fault traced by trying a cassette or listening through headphones, in order to decide if the fault lay in the loudspeakers or the turntable deck. New modules may be added into spare slots, providing only that they are compatible. Similarly, the modular organisation of our brains and minds may allow us to develop new cognitive components and interface them with old ones to create new skills and capabilities. Modules for reading and writing may be just such, the CD players of mind/brain evolution, recently developed but ready to slot in to our cognitive stacking systems.

Simon and Marr elevated modularity to a general principle of systems design, while Fodor posited that modular organisation is a necessary condition for the exploration of cognitive functions; he suggested one or two of these cognitive functions which are clearly modular, language and perception, perhaps. He claimed that **only** these were capable of being studied scientifically; those which are **not** modular would be impossible to analyse, such as the higher associative abilities. Fodor claims that language and perception are structured as modules, while the general cognitive abilities-judgement, logic, inference-do not penetrate them. He describes modules as having ten properties:

1) They are **domain specific**;

2) Their operation is **mandatory**;

3) Central systems have limited access to the representations computed by input systems;

4) Their operation is **fast**;

5) They are informationally **encapsulated**;

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[375] Marr, Early Processing of Visual information, 1976.

6) They have **shallow** outputs;

7) They are associated with **fixed neural architecture**;

8) They exhibit **characteristic and specific breakdown patterns**;

9) Their ontological development exhibits a characteristic pace and sequencing;

10) They are **innate**, a genetic endowment.[376]

To be **domain specific**, a module must be able to accept only one particular sort of input: for example, a module processing the emotional expression of faces would not also be able to process the emotional tone of voices.

To be **mandatory**, the modules operate in an unstoppable fashion, they are beyond voluntary control; if the appropriate input is present a module will carry out its particular processing whether the owner wishes it or not. This is probably more a property of **input** modules than output ones.

Fodor suggested that whereas input processes to do with perception of the external world, and possibly output processes to do with the control of action upon the world, are modular, there may be **central** parts of the mind which are **not** modular in their organisation. Higher level thinking processes, such as reasoning, decision making, the formation of beliefs, and so on, are the product of operations which are **not** informationally encapsulated, **not** mandatory, **nor** domain specific; these are the central processes which are not amenable to scientific investigation, or so he says.

Modules operate **fast** because it is a **survival characteristic**, something which would have encouraged their development and prolonged the existence on this Earth of their owners: it would certainly be survival-enhancing to be able to automatically recognise a lion or tiger shape on the savannah and act as swiftly as possible on that identification by running in the opposite direction. Presumably we possess only the genes of those who managed successfully to do just that.

Modules are **informationally encapsulated**, and so carry on their form of processing in complete ignorance of, and isolation from, what is going on elsewhere in the cognitive system; **face identity** processing is therefore totally separate from **facial emotion** processing.

Output from the modules is **shallow** because speed forbids detail: the richness of particularity cannot emerge from something which operates on a survival reflex; this means that if a dog were to bound up to us, wagging its tail, we would not be

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376 summary in Marshall, J.C., Multiple perspectives on modularity, **Cognition**, 17, pp. 217-218, 1984.

able to identify it as anything more than **dog**; we could not further particularise it as a poodle, an Alsatian, or an Irish wolfhound. Central cognitive functions must supply the fine detail.

Neurological specificity, close association with identifiable neural architecture, is a characteristic of modules which obviously makes them an essential theoretical foundation for disciplines such as Cognitive Neuropsychology, as do numbers eight and nine on the list. Number ten is rather controversial: if reading and writing are considered as part of our **biological** heritage we are tip-toeing into the murky area of the "Inheritance of Acquired Characteristics", the 19th century Lamarckianism which remains anathema to all Neo-Darwinists. I.A.C. claims that the son of a blacksmith will **directly** inherit his father's big muscles rather than having to build them up himself if he decides to follow in the family trade; it is declared that the **environmental** adaptation of the individual will alter his or her **genetic** nature.

It does appear, however, that the modules for reading and writing behave just like any other cognitive modules; nevertheless, they are artificial, culturally transmitted skills which, until recently (historically speaking), have been acquired by very few people-there has been no time for them to have become part of our DNA through mutation and natural selection. The only possible explanation is that modules for reading and writing are themselves formed from clusters of relatively simple, and evolutionarily earlier modules drawn from many different areas of the brain into a form of bonded co-operation to subserve the new, complex cultural demands. The skills of reading and writing therefore come into existence as emergent properties of the lesser modules' co-operation in the larger systems. Other skills, such as those of mathematics and art, may arise in a similar fashion.

Perhaps one way to understand this is to compare it with the emergence of white light from the combination of all the colours of the rainbow, as discovered by Newton. Only when we use a prism to split white light up into its components do we see its true nature-or, perhaps, by the anti-reductionist view, there may be no such thing as a "true nature", only different truths at differing levels of analysis.

Problems With Fodor's Modular Theory

Semenza, Bisiacchi, and Rosenthal (1988) have pointed out several problems with Fodor's modular theory.[377] The normal hierarchy of knowing about something is that, firstly, we must know **what** has to be performed; secondly, we must know **why** it is composed of the various sub-goals of the task; thirdly, we must know **how** it can be carried out; lastly, we must know the **means** by which it can be executed, the neural mechanisms, or the behaviours, in this case. Fodor's theory begins at the brain parts and behaviours level, at implementation, rather than at the task level, and so he has it the wrong way round. Fodor implies that **what** has to be done is

[377] Denes, G., *et al*, **Perspectives on Cognitive Neuropsychology**, Erlbaum, 1988

determined by how it is done. The determination of what are meaningful components for a task depends on the theory of the task-unfortunately, conventionally described by those often confusing box-and-arrow diagram models-**not** on the brain parts which carry it out, nor the behaviours which we observe. This has the necessary implication that to say something is modular may well be meaningless, because **anything** may be viewed as a module.[378]
Rosenthal (1988) says that there is no reason to believe that a module is made up of neural mechanisms specific **only** to that modular task; he infers that neural mechanisms, in fact, participate in a number of sub-tasks. It does not seem feasible that all the different parts of the brain are specialised for **one** and one only task in whatever module they find themselves, on a strictly one for one basis. Indeed, it would be a most uneconomical design if that were the case. There is much more likelihood that the brain is like the hand, a **multipurpose structure**, flexible enough for its individual components to participate in many different functions, like scratching one's head, picking one's nose, playing the violin, punching someone, or painting the *Mona Lisa*.. The hand can be adapted to perform all these functions and thousands more. A computer may be designed so that one component does only one job, but we are not.

It is always possible to explore a device without truly understanding its task, as we do the brain, but if we try to create a system without an adequate theory of what it has to do, it simply will not work, or so says Rosenthal.[379] Similarly, some tribes of the Pacific during the Second World War constructed mock airplanes shaped by what they saw flying over them, without any understanding of what made them work. They worshipped them, hoping they would fly. Naturally, none ever did. As long as we do not understand the brain, any effort to create an adequate cognitive theory of its tasks and processes will be doomed to failure. This is one of the standard arguments often employed against the Artificial Intelligence (AI) program, which seeks to build a computer which will imitate the intelligence and awareness of a human being, and so will be indistinguishable from one (thus passing the "Turing Test"). Nevertheless, without an adequate understanding of what the brain does, a theory of task, AI will not fly, either.

Perhaps the most unacceptable element of Fodor's modular theory is its assumption that there is a central, module-controlling cognitive field or executive, a "homunculus", a little man, the gnome in the cuckoo clock who makes it work. Inevitably this leads to the question "Who controls the controller?" and thence to an unpleasant infinite regression of little creatures, each one sitting on the other's shoulders, each controlling the one below it, ad infinitum. There is an element of religious faith in all this, a touching trust that somewhere, somehow, Someone or

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378 **Ibid**, pp. 18-19.

379 Rosenthal, V., Does it Rattle When You Shake it? Modularity of Mind and the Epistemology of Cognitive Research, in Denes, *et al*, Footnote, p. 39, 1988.

Something is in charge, directing all our actions. The homunculus is simply another name for the spirit, derived from God. It is appalling that such an otherwise relentlessly "scientific" discipline as Cognitive Science/AI should rely on the Aristotelian concept that "everything must be driven by something", a concept outmoded in science in the 17th century. It was once believed that the planets were propelled around their orbits by a mysterious motive force, that every body in motion necessarily needed some of this. From the time of Galileo, Kepler, and Newton this belief was abandoned, being replaced by the concept that a body will continue to move until acted upon, that every body moves in various directions at once because that is the nature of the dynamic universe. Likewise, there is no reason to believe that minds have a central executive, a "motive force", a conductor for the modular orchestra.

The famous Mind/Brain problem is often invoked in any such argument, a problem which has exercised the modules of the greatest scholars and philosophers of the world for generation after generation. Expressed simply, it is:

How can the mind, something without material substance, exert a controlling power over the too, too solid flesh of the brain and the body; how can the "I" possibly be able to raise an arm if it is only by the power of some insubstantial Will? Or are we all Uri Gellers, moving our bodies about by the mystic powers of our minds? Parapsychology, therefore, could be seen as concerning itself with those people in whom the ability to produce action at a distance was greater only by degree than that of the rest of us.

Followers of Fodor may claim that we are a long way away from his conception of the central executive when we talk of the Will or the Spirit; nevertheless, the efficiency with which his magical genie functions may determine how closely it can integrate the modules and hence produce the "g" or intelligence of the individual.[380] The IQ testers, the psychometricians, will tell us that characteristics such as speed of reaction time or inspection time are a function of cognitive efficiency: the "bright" are actually "quick". Either a feeble or inefficient central executive or damaged modules may produce mental handicap of a general or specific type, according to this sort of theory; in the first instance, overall poor performance without any specific deficit will occur, while in the second instance the sort of bright individual who may suffer from localised deficits such as dyslexia or prosopagnosia will result.

Michael Howe (1989) has made the case for the independence of human skills, his version of a modular theory of mind organisation.[381] He says that the findings by

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380 A version of this theory is discussed by Dr Neil O'Connor in Intelligence, Handicaps and Talents, **The Mental Retardation and Learning Disability Bulletin**, 15 (2), pp. 41-56, 1987.

381 Howe, M., **Fragments of Genius: The strange Feats of Idiot Savants**, Routledge: London and New York, 1989.

the psychometricians, the intelligence testers, that there are positive correlations between measures of a person's success at different skills gives no grounds at all for concluding that the measured skills must be centrally controlled; the individual measures and the correlations between them are nothing more than end products of whatever processes gave rise to them. Many tasks require more than one mental skill, and, moreover, many skills have shared elements. Hence the correlations between measures of performance at two tasks may reflect the fact that to some extent each is drawing on the same skills or on skills that have elements in common. In addition, there will be a correlation in measures of performance to which personal attributes such as attentiveness, anxiety to succeed, interest, knowledge, patience, competitiveness, assertiveness, perseverance, and self-confidence all contribute. Howe claims, very strongly, that as a consequence it is quite unnecessary to introduce the idea of a governing general mental ability, intelligence, or a central executive.[382]

When we consider people such as idiots savants, who have a low **overall** cognitive ability but possess one or more talents or skills in art, or music, or calculating, or if we look at dyslexics, who very often have high cognitive ability but **one** single area of cognitive deficit, we see some of "Nature's Experiments", demonstrating the likely truth of modularity theory by the great disparity which they show between general ability and specific ability. The psychometricians who adhere closely to a theory of general intelligence, or "g", have no explanation for such individuals, while Fodor's particular brand of modularity theory, with its central processor, the "horizontal" element uniting the "vertical" elements of the individual modules, looks a little dubious in the light of Howe's arguments.

Howard Gardner's theory of multiple intelligences,[383] postulates seven+ abilities, including maths, spatial skill, music, kinaesthetic skill, as co-operating units within our general intelligence. These are models in the tradition of Guilford and Thurstone; they clarify the nature of differential abilities, where non-modular conceptions do not. Gardner mentions Alan Allport as another who endorsed the notion that human cognition consists of a number of "special purpose" cognitive devices.[384]

Modules are seen by Gardner as having the following characteristics:

1) They are special purpose information processing devices;

2) some are shared with animals (face perception), others are peculiarly human (syntactic parsing);

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[382] **Ibid**, pp. 73-74.

[383] Gardner, H., **Frames of Mind: The theory of multiple intelligences**, Basic Books, 1983.

[384] Gardner, **Frames of Mind**, p. 55.

3) some are molecular (line detection in the visual cortex, as discovered by Hubel and Weisel), others are molar (control of voluntary action);

4) each mechanism operates according to its own principles and is not "yoked" to any other;

5) operation is initiated solely by the presence of forms of information to which each one is sensitised; they are cognitively "encapsulated";

6) consciousness has a limited control over some of these mechanisms (but, as in the case of the persistence of illusions even when they have been consciously detected, consciousness is quite often helpless once they have been triggered into action);

7) there is no central information-processing mechanism which decides which computer to invoke;

8) there is no general working memory plundered by the different mechanisms; each one has its own;

9) most of the mechanisms work together in the carrying out of complex actions;

10) there is heterochrony, different neural systems developing at different rates and in different ways, depending on the recency of their evolution and the needs and adaptations of the infant or child;

11) the mechanism can be destroyed or spared by lesions to particular areas of the brain (there appears to be little consideration of the possibility of the destruction or sparing of parts of the mechanisms only; it is an all-or-nothing scenario);

12) evolutionary antecedents may be found in other animals, perhaps in the form of isolated computational abilities, which are bound together in one system in humans;

13) they may be detected by psychological tasks which interfere or fail to interfere with each other, or tasks that transfer or do not transfer across different contexts, or the identification of forms of memory, attention, or perception peculiar to one kind of input;

14) each mechanism has its own procedures and biological bases, much as the other organs of the body, the kidney, the liver or the lung, and is just as capable of working together, as in the healthy human being, or working alone, or in reduced capacity or combinations, as in the damaged individual.

Finally, Gardner warns that such mechanisms are really fictions, reifications of entities which in actuality are continuous and between which can be detected no sharp discontinuities-they are not physically verifiable structures.[385] Nevertheless, it is easy to see how similar Gardner's intelligences are to Fodor's modules, with the notable exception that with Gardner there is no central executive or processor.
It is interesting to note that Gardner's book was published quite soon after Fodor's; modularity was obviously "in the air" in the early '80s. John C. Marshall[386] at the beginning of a thorough survey of modularity theories says:

Modularity is clearly a term whose time has come...Neuropsychology-the currently fashionable name for phrenology-has unambiguously adopted the principle of modularity[387]

Marshall quotes Shallice:[388] "...computational independence is made easier by separability of physical processes in the brain...", calling this an "...extended principle of modularity", which would predict that brain lesions would selectively perturb "...performance of any task that makes heavy use of the subsystem which would be impaired", while leaving performance on other tasks essentially intact.[389] Gardner, in his reply to Fodor,[390] says that:

In my view, a fully encapsulated module is an ideal observable only in freaks (for example, idiot savants or autistic children).

He asserts that there is a core computational capacity at the centre of each intelligence/module, which can be observed in uninterpreted form only in early life, cultural influences strongly fashioning them, "melting" the "capsules" over the life span,[391] in a perpetual reorganisation. No central executive is required by such a theory, says Gardner, where modules cooperate and "talk" to each other. Conceptual rigidity exists even in Gardner's theory, nonetheless, with developmental change allowed, but not demand-based change or energy-flow change on a moment-to-moment basis.

Cognitive scientists, apart from their faith in the presence of something which must be in charge and directing our actions, are also constrained in their thinking by the means whereby they theorise: when one uses schematic representations consisting of little squares connected by lines and arrows with which to construct mental models, the human mind tends, quite naturally, to be presented by them as being made up of boxes connected by electrical wiring, or chips connected by printed

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385 All characteristics have been drawn from Gardner, **Frames of Mind**, pp. 55-70.
386 Marshall, J.C., Multiple perspectives on modularity, **Cognition**, 17, 1984, pp. 209-242.
387 pp. 209-210, **Ibid**.
388 Shallice, T., Neurological impairment of cognitive processes, **British Medical Bulletin**, 37, 187-192.
389 Marshall, Multiple perspectives on modularity, pp. 210-211.

390 Gardner, H., The centrality of modules, p.13, Fodor, **Precis of Modularity of Mind**.
391 p.13, **Ibid**.

circuits. This is far too closely tied to current computer hardware technology, in much the same way that earlier models of the brain's structure and workings were tied to contemporary technology, as in the 'enchanted loom', or the flickering lights of a telephone exchange. Such confining conceptualisations inhibit the creative imagination and may well prove misleading in the long run, in a similar way to clinical diagnostic categories.

However, even Fodor, in his list of characteristics of a module, includes the necessary mapping-on to areas of neural architecture. These structures cannot be conjured up as boxes in a wiring diagram or flow-chart and reified into the brain without neurophysiological justification. Nor can the mind/brain problem be ignored by re-naming the components and processes, or pushing the problem up to a higher level of description, or down to a lower one. Endlessly proliferating terms such as "horizontal processes" and "vertical processes", "central executives" and "encapsulated modules" do not get us any further than those thinkers who saw mind as one thing and brain as another. What is required to end this sterile debate is a cross-fertilisation of new ideas from other fields, new ideas which may permit the discovery of modules on both a cognitive and neuropsychological level, and provide some way in which primitive dualism may be knitted together into a more rational monism. On the way to these larger matters, considered in the final chapter, light may be cast on the nature of the idiot savant, and the dyslexic.

SUMMARY OF HYPOTHESES

The hypotheses which follow have been generated from this necessarily very lengthy literature review; included among them are those created by assuming an association of lower cognitive functioning in the student population, as measured by the tests used here, with milder forms of the pathologies found in the savants and dyslexics. Doodling, for example, seemed a way not used before to investigate hemisphericity, if it is assumed that geometrical versus organic doodles represent left versus right hemisphere styles. So-called "deep" daydreaming has nothing to do with either deep dyslexia or deep semantic word processing, but rather implies that someone addicted to daydreaming to such an extent that physical efforts may sometimes have to be taken to get them to return to the real world is daydreaming very deeply, indeed. This may well relate to tendencies in individuals to live in a fantasy life, or actively seek to escape from harsh reality-it seemed likely that they would score less well than those who were always "wide awake", as this tendency resembled the autistic or schizophrenic extreme behaviours. Reality loss, too, seems an "early warning" of schizophrenic tendencies, the sense that when in a crowded street everything has become unreal, the buildings and people may prove to be made of insubstantial stuff unless one reaches out to touch them and make sure. If all psychological disorders are inherent in everyone, to a greater or lesser degree, and those individuals who manifest them in a florid form are simply those at one end of a continuum, then the cognitive effects, reduced to scale, will accompany the milder versions, as well. From this perspective there is, therefore, no such thing as absolute health or absolute sanity. As left-handedness and dyslexia were associated by Norman Geschwind, and dyslexics very often have a marked wider Performance/Verbal IQ scores differential than normals, it seemed a good idea to replicate to a great extent Levy's 1970 work with left-handers from a similar University population.

Hypotheses:

1) Having artistic and musical parents will produce lower test scoring in their sons or daughters.
2) Hand will significantly dichotomise the sample, with right-handers scoring more highly than left-handers on test items requiring left hemisphere functions.
3) Familial left-handedness will have a lowering effect on the scoring.
4) Allergies will be associated with mathematical ability and higher test scoring.
5) Familial allergies will be associated with higher test scoring.
6) Asthma will be associated with lower test scoring.
7) Familial asthma will be associated with lower test scoring.
8) Myopia will be associated with higher test scoring, more females than males being myopic.
9) Familial myopia will be associated with higher test scoring.
10) Musical ability, an art, will be associated with lower test scoring.
11) Mathematical ability will be associated with higher test scoring.
12) Need to draw will be associated with art ability, monotalent (having but one area of true ability), and low test scoring.
13) Imaginative drawing (that does not require copying from life) will be associated with high test scoring.
14) Clumsiness will be associated with low test scoring and poor right hemisphere functioning.
15) Colour or black-and-white preference: colour preference will be associated with art ability, painterly preference and lower test scoring; black-and-white will be associated with math ability and graphic preference, together with higher test scoring.
16) Doodling: geometrical doodling will be associated with mathematical ability and higher test scoring; organic doodling will be associated with artistic ability and lower test scoring.
17) Art preference: realistic preference will be associated with a right hemisphere profile and the Arts; abstract preference will be associated with a left hemisphere profile and the Sciences.
18) Persistent child illness will be associated with low test scoring and artistic and/or musical ability.
19) Sociability: dislike of other people will be associated with artistic ability.
20) Hyperactivity will be associated with low test scoring.
21) Deep daydreaming will be associated with low test scoring, artistic and/or musical ability, and a right hemisphere profile.
22) Loss of reality will be associated with low test scoring, artistic and/or musical ability.

23) Early speech, early walking, and early reading and writing will associate with each other and with higher test scoring.
24) Early perspective will be associated with higher right hemisphere scoring and, as it indicates all round precocity, higher scoring overall.
25) Graphic/painting preference: graphic preference will be associated with higher left hemisphere scoring and therefore overall higher scoring; painterly preference will be associated with lower scoring all round.
26) Art ability will be associated with lower scoring.
27) Summer birth will be associated with higher scoring.
28) Science students will score more highly than Arts students on the right hemisphere tests and more highly overall.
29) Students with light hair and eyes will score less well over all tests (including Reaction Time tests) than students with dark hair and eyes.
30) Males will score more highly than females over all tests.
31) Those born in the late winter months of February, March, April, and May will score less well than those born at other times of the year.
32) Left hemisphere dominant students will score more highly overall than right hemisphere dominant students.
33) Students who are antisocial will score less well than those who like being around people.
34) Left-handers will show a wider difference than right-handers between Appositional and Propositional scores.

METHOD

Gordon's Cognitive Laterality Battery

Harold Gordon of the University of Pittsburgh has devised a battery of cognitive tests, eight in all, which seek to provide a profile of those tested, showing a tendency to use brain skills conventionally identified with either the left or the right hemisphere (sample test blanks are in **Appendix II**). The sub-tests used are generally well-validated by comparison with the performance of clinical populations, and normed against a large sample; over ten years or more studies have used the CLB in its several evolutionary stages; this research uses the version from 1985 [published 1986].

Gordon's adult (20-65) raw score norms (means and Standard Deviations) as shown in his target article from 1986 which presented the Cognitive Laterality Battery in the form used in this research are as follows [**TABLE FIVE**]:

All (n=251)	**Males (n=89)**	**Females (n=162)**	
112.86 (48.96)	119.43 (56.82)	108.65 (43.88)	**Serial Sounds**
250.54 (71.94)	247.70 (67.93)	251.92 (74.83)	**Serial Numbers**
42.35 (11.06)	40.76 (11.46)	43.12 (10.84)	**Word Production-L**
32.28 (6.77)	30.27 (7.18)	33.27 (6.28)	**Word Production-C**
79.39 (16.02)	76.90 (14.61)	80.68 (16.60)	**Localisation**
13.47 (4.48)	15.42 (4.43)	12.40 (4.14)	**Orientation-3d**
11.70 (4.36)	11.42 (4.84)	11.85 (4.08)	**Form Completion**
22.66 (5.70)	24.70 (5.07)	21.53 (5.74)	**Touching Blocks**

TABLE FIVE: GORDON'S CLB ADULT RAW SCORE NORMS (MEANS AND STANDARD DEVIATIONS) [1986]

Gordon said there was no convenient way to compare difficulty among the tests because the tests and scoring methods were so different. Estimates based on comparing the population means to maximum scores made Serial Sounds and Orientation-3d as the most difficult of the sub-tests, with the verbal fluency and Form Completion tests next. 75% of the adults tested by Gordon were college [University] students, with perhaps more postgraduates than undergraduates. 25% were non-college subjects, so perhaps increasing the variability of the sample; certainly the UK sample had very few of these latter individuals and thus may be more homogeneous and higher-scoring than the USA sample [such appears to be the case-see 'Results'].

Reliability

A definition of Reliability could be that it is the extent to which the measurements of any instrument contain variable errors, so that these errors differ from application to application of the instrument over time or within one observation. Often, statistical and experimental design manuals speak of the difference between physical measures and measures in the social sciences, the latter always being regarded as more subject to error; however, modern physics sees the act of measurement itself as affecting the thing being measured, as it certainly does in the social sciences. Absolute reliability seems, therefore, an ideal approached asymptotically, and often not very closely at all, in any science. All measures, in physics or psychology, are indirect, the **true component** made hazy by the fog of the **error component**. It follows that reliability may also be seen as the ratio of the true score variance to the total variance in the scores as measured. Essentially, the true score can never be known, but only estimated indirectly by the use of methods such as test-retest, parallel-forms, or the split half method. Test-retest involves the administration of a measuring instrument to the same group of persons at two different times; correlations are calculated between the two measures. Parallel forms requires two forms of the measuring instrument which are essentially similar; correlations are calculated between their scores on the same group of persons. The split-half method involves treating two or more parts of the instrument as a separate scale-perhaps odd and even questions-the two sets are treated separately and scored as such, correlation once more being used to estimate similarity and therefore reliability.

The internal reliability for each sub-test in the CLB, rather than individual items (e.g., one string of recalled digits), was claimed to be good by Gordon: he used a measure called Cronbach's alpha, which compares each element with every other element. Alphas ranged from .682 for Serial Numbers to .890 for Word Production-L, as follows [**TABLE SIX**]:

Cronbach's Alpha	Split half	Sub-test
.740	.659	**Serial Sounds**
.682	.466	**Serial Numbers**
.890	-----	**Word Production-L**
.778	-----	**Word Production-C**
.707	.548	**Localisation**
.794	.669	**Orientation-3d**
.778	.562	**Form Completion**
.876	.786	**Touching Blocks**

TABLE SIX: RELIABILITIES FOR THE COGNITIVE LATERALITY BATTERY-ADULTS (N=250)

Since the Serial Numbers sub-test has items that differ widely in maximum possible scores, from 4 in a series to 9 in a series, Gordon standardised the raw scores by dividing the means by their standard deviations, thus increasing the alpha to .710 for Serial Numbers, although similar transformations for the other sub-tests did not affect the alphas. Gordon takes this to mean that, in general, each of the CLB sub-tests is internally reliable. In the above **Table Six** can be seen, as well, values for split half tests, which on the whole were not as high as the Cronbach alphas-however, they still appeared reasonably good. Gordon makes the proviso that the reliability is reduced if the tests are split in two parts, although that applies to the reliability of any instrument split in twain.

Test-retest reliabilities are quite good, as well: correlations were in the range .7 to .9 over one week intervals. The only sub-tests not showing some improvement of performance were Localisation and Serial Numbers for males, while for females the test-retest values were very similar. The only notable difference was that for males the Serial Sounds sub-test was the least reliable and for females it was Serial Numbers.

Validity

Validity could be defined as whether or not one is measuring what it is believed one is measuring. **Content validity** is one kind, usually divided into **face validity** and **sampling validity**: face validity is a judgement concerning how closely the instrument measures what it appears to measure, made by the experimenter or external judges. Sampling validity in the context of the CLB would be "Does the CLB adequately measure the content of the properties it has been assumed it measures?" Do the sub-tests used delimit the full range of those properties, Appositionality and Propositionality? Are they adequate for the task that they are required to carry out? This, of course, requires the experimenter to know quite exhaustively the elements from which those two theoretical constructs have been derived; unfortunately, brain science is not yet that advanced, although adequate sketches are possible. **Empirical validity** is another kind, with **predictive validity** as perhaps the most widely used test of this; scholastic test grades may be compared with psychometric test scores and correlations or regressions calculated, for example, with a view to using one to predict the other. One of the problems with this approach is that any correlation arrived at may be due, not to a relationship with each other, but rather to a shared relationship with a third measure which had not been examined. Correlation, as is often said, does not imply causation. It may be, however, that the CLB has predictive validity for identifying poor reading grades or good mathematical ability, or other skills, as shown by some of the published research which has used the CLB.

Construct validity involves relating the CLB, for example, to the theoretical concepts which it was designed to demonstrate, e.g., Appositional and Propositional thinking. Construct validity is demonstrated by showing that such relationships actually do hold. While the Factor Analysis carried out by Gordon on his data from the normative population at Pittsburgh seems to show a quite clear dichotomy between the Propositional and Appositional sub-tests, this is an interpretation only, of course. Nevertheless, the sub-tests of the CLB were chosen from long-used neuropsychological or psychometric instruments known to be adversely affected by brain damage in one or the other cerebral hemispheres. For example, performance on the Form Completion sub-test was well-known to be poor after right hemisphere insults. The assumptions on which the CLB was based are that activity in the neurosystem related to Appositionality is more distributed to or active in the right hemisphere, with the Propositional neurosystem more distributed to or active in the left, with precise anatomical locations remaining unfixed. Another way of looking at construct validity for the CLB is that it would be expected that correlation coefficients for the sub-test scores expected to measure A, even though they use different methods of assessment, would be higher between each other than those between them and the other sub-tests intended to measure B, something which does appear to be the case [see Factor Analysis of both USA and UK samples].

Gordon claims that the sub-tests are brain-validated, that they measure what they are expected to measure;[392] another example would be Spatial Rotation-3d, which

[392] Gordon, H. W., The Cognitive Laterality Battery: Tests of Specialised Cognitive Function, **International Journal of Neuroscience**, 29, pp. 223-244, 1986.

brain lesions in the right hemisphere appear to make more difficult. Gordon cites a study (Shenkman, Gordon, and Heifetz, 1980) which looked at 15 schizophrenics and found they had a right-hemisphere (Appositional) profile caused by lower scoring on the tests identified as left-hemisphere.[393] Left hemisphere lesions reduce verbal fluency, a constantly recurring finding, with sequencing or seriation something which probably derives from the structure of language itself and is, apparently, impaired in left-brain damaged nonaphasic patients. In dyslexics, sequencing of letters and numbers is a known problem, something Galaburda among many other researchers has indicated may be due to chaotic neural organisation in the left hemisphere. Depressives appear to have a left-hemisphere profile (Kushnir, Gordon, and Heifetz, 1980).[394] Interestingly for the purposes of this study, Gordon found (Gordon, 1983) that gifted children with a left-hemisphere profile tended to enrol in creative writing classes, while those children with a right-hemisphere profile tended to enrol in a model-building class.[395] It seems to the present writer that Gordon has a good case that his A and P tests actually do measure to some extent what they are thought to measure; even in its earlier versions this appears to have been confirmed (Bentin and Gordon, 1979).[396]

This conclusion is reinforced when other studies using the CLB are considered; these have found, for example, that dyslexic children consistently performed above average on A-type tests, and, as was predicted, poorly on P-type tests;[397] that 'natural' fighter pilots, 'Top Guns', were likely to have an A-profile, as opposed to helicopter pilots or navigators;[398] that managers able to deal with multiple inputs in an organisation were more likely to have an A-profile than managers able to deal only with one thing at a time, sequentially, and therefore judged to be less capable, having a P-profile;[399] that FSH and testosterone levels were positively correlated with visualspatial abilities as measured by the CLB-something which, additionally,

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393 Shenkman, A., Gordon, H.W., and Heifitz, A., Cognitive asymmetries in acute schizophrenics, paper presented at the 8th Annual Meeting of the International Neuropsychological Society, San Francisco, 1980.

394 Kushnir, M., Goedon, H.W., and Heifetz, A., Cognitive asymmetries in bipolar and unipolar depressed patients, paper presented at the 8th Annual Meeting of the International Neuropsychological Society, San Francisco, 1980.

395 Gordon, H.W., The learning disabled are cognitively right, **Top. Learn. Learn. Disability**, 3 (1), pp 29-39, 1983.

396 Bentin, S., and Gordon, H.W., Assessment of cognitive asymmetries in brain damaged and normal subjects: Validation of a test battery, **Journal of Neurol, Neurossurg. Psychiatric.**, 42 (8), pp 715-723, 1979.

397 Harness, B.Z., Epstein, R., and Gordon, H.W., Cognitive profile of children referred to a clinic for learning disabilities, **Journal of Learning Disabilities**, 17 (6), pp. 346-352, 1984.

398 Gordon, H.W., Silverberg-Shalev,R., and Czernilas, J., Hemispheric asymmetry in fighter and helicopter pilots, **Acta Psychologia**, 52, pp. 33-40, 1982.

399 Gordon, H.W., Management Success as a Function of Performance on Specialised Cognitive Tests, **Human Relations**, Vol. 40, No. 10, pp. 671-698, 1987.

has some relevance to the Geschwind and Galaburda theory of cerebral lateralisation.[400]

Gordon was careful to lift the two sets of sub-tests away from strict identification with one or other cerebral hemisphere; the simplistic dichotomy of left-brain/right-brain which has caused a great deal of controversy and attracted criticism for its primitive parcelling-out of functions to one side or the other was avoided by using a Factor Analysis to identify the unity of the two sets of sub-tests, as they adhered to either one of two Factors. Nonetheless, there is a strong temptation to describe the results from such a test in neuroanatomical terms.

The Sub-tests
In greater detail, the sub-tests are:

a) **Serial Sounds**, after a period when recognition is well-established, subjects listen to sounds played from an audio tape such as a dog barking, horse neighing, bugle blowing, and doorbell ringing in sequences which gradually increase in number of sounds; the object is to remember the order correctly and write them down in that correct sequence. In the scoring, credit is given for partial series. The sounds are played from a tape at 2 second intervals within each sequence. At the end of each sequence a three pulse tone indicates when the subject may begin to write. Initially, pictures slides are shown to identify the sounds being played. Series B, the longer series, is used with individuals from age 15 to 65, with a maximum score of 290.

b) **Serial Numbers**, where numbers are spoken in sequences which lengthen from three and then decrease to 6 from a maximum of nine; the object, again, is to write down the correct sequences of numbers; partial series get credit in the scoring. It is very like the Wechsler digit span; each digit is presented at 1 second intervals and there are 11 sequences in total, although the first two, of 2 and 3 numbers, are not scored. The scoring is the same as for the preceding sub-test, with a maximum of 378.

c) **Word Production-Letters**, where subjects are asked to write down as many words as they can beginning with a specified letter in the space of one minute. Scoring is a simple total of all the words from three efforts starting with three different letters (C, F, L), which are not proper names or different tenses.

d) **Word Production-Categories**, is similar, where a category is stated, for example, flowers, and once more it is the number of words produced within one minute in that category which is scored. Two categories are given, food and animals, the score being the total for both categories.

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[400] Errico, A.L., Parsons, O.A., Kling, O. Ray, and King, A. C., Investigation of the Role of Sex Hormones in Alcoholics Visuospatial Deficits, **Neuropsychologia**, Vol. 30, No. 5, pp. 417-426, 1992.

e) **Localisation**, where small crosses are displayed for three seconds in a rectangular frame on a projection screen 24 times; subjects are required to mark their answer blank rectangles where they thought they saw the crosses. Scoring is the total error in millimetres from the correct positions on all slides. The slides are shown in pseudorandom order, counterbalanced so that the same number of crosses appear in each of the four quadrants This sub-test is the only one where a low score is a good score.

f) **Orientation-3d,** where three-dimensional S-shaped constructions of 10 stacked cubes are presented on a screen in sets of three 24 times; the task is to twist and turn the shapes in order to find out which two are the same. The third is a mirror-image which can never be the same as the other two. The paired two are circled or otherwise marked by the subject on his or her answer blank; 15 seconds are allowed for selection of the two constructions which are alike. Scoring is the total of correct rotations. [Shepherd and Metzler, 1971][401]

g) **Form Completion (closure)**, where partially erased silhouette drawings, white on blue, of common objects are projected on the screen; the subjects must use their imaginations to complete the shapes and decide what they represent, writing this down in a word or two. Six drawings are shown at a time, with 45 seconds per slide allowed; four slides are shown, with a total of 24 items. This Gestalt test is, again, scored by adding the number correctly titled. [Thurstone and Jeffrey, 1966][402]

h) **Touching Blocks**, where stacks of 7-10 stacked rectangular blocks are projected on the screen, some numbered; the blocks are stacked in such a way that some two to eight blocks may be adjacent to, touching, any one block. The task is to count up the blocks touching above, below, and on each side of the numbered blocks. For each stimulus slide, five of the rectangular blocks are numbered; the subject is allowed 45 seconds to indicate the number of touching blocks for each of the numbered blocks. There are six slides, giving a total of 30 items. Scoring once more is a simple total of correct answers.[MacQuarrie, 1953][403]

When the scoring is carried out, it is possible to derive a Propositional score from the four Verbal-sequential tests, and an Appositional one from the remaining Visual-spatial sub-tests; the Propositional score is then taken away from the Appositional, leaving what Harold Gordon calls a "Right-hemisphere profile", the extent to which the individual or group excels at Visual-spatial tests, or the extent to which they are less good at Verbal-sequential tests. Obviously a poor performance

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401 Shepherd, R.N., and Metzler, J., Mental rotation of three-dimensional objects, **Science**, 171, pp. 701-703, 1971.

402 Thurstone, L.L., and Jeffrey, T.E., **Closure Speed**, Chicago: Industrial Relations Center.

403 MacQuarrie, T.W., **MacQuarrie Test of Mechanical Ability**, Monterey, CA.:California Test Bureau, 1953.

on the Propositional tests will, providing the performance on the Appositional side has been normal or just better than the Propositional scores, give a "Right hemisphere profile", without implying that the individual or group is at genius level in the Visual-spatial area. The profile so derived is called a "CLQ", or Cognitive Laterality Quotient.

Finally, the scores overall are added together and divided by the number of sub-tests in order to give a measure of cognitive ability, the "CPQ", or Cognitive Performance Quotient. This is similar to a score in intelligence, although the CLB does not measure everything measured in IQ tests. Although many of Gordon's sub-tests are derived from IQ tests, he is very clear that he intends them to be used in a neuropsychological context, deriving their reason for use from clinical studies of brain lesions and pathologies. Nonetheless, some of Cattell's primary factors are tested by Gordon's CLB:

"**W**"=Word fluency, the rapid production of words, without semantic connection but conforming to an initial letter requirement (found by Cattell in 1933, and used ever since in IQ tests);

"**V**"=understanding words or ideas; it is likely that this plays a great part in successful performance on the "Word Production-Categories" sub-test, with some aid from "W", and from Fl, or "ideational fluency". "V" is supposed to be the most reliable indicator of "crystallised intelligence".

"**Ms**"=span memory, the short-term recall of digits or letters, as used in the Wechsler IQ tests. It is uncertain if the recall of series of sounds taps the same memory.

"**S**"=spatial factor; the ability to visualise two- or three-dimensional objects when their orientation is changed. The 3d Spatial Rotation-Orientation sub-test clearly fits this factor.

"**Cs**"=speed of closure factor; this apparently taps the ability to quickly complete a gestalt when parts of the stimulus are missing. Interestingly, speed of visual closure correlates 0.610 with word fluency. It may then be possible to predict that Form Completion, the Gestalt sub-test, will load quite strongly on any verbal-sequential Factor in a Factor Analysis of these research results.[404]

Kline (1991) states that verbal ability is highly loaded on intelligence tests, especially those used for selection to Universities and schools. He says that people in the arts

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404 all descriptions of the Cattell primary factors taken from Kline, P., **Intelligence: The Psychometric View**, London: Routledge, 1991.

are usually high on this factor, although it should not be confused with intelligence as such, because many scientists are relatively weak in verbal ability.

Second order ability factors have been derived from the intercorrelations of the first order factors:

"**gf**"=fluid intelligence, which includes memory span, flexibility of closure and intellectual speed, tested in the CLB by the two sequential memory sub-tests and the Gestalt Form Completion sub-test, together with the overall fast timing of the whole battery.

"**gc**"=crystallised intelligence, tested by the verbal fluency tests.

"**Pv**"=Visualisation, tested by the Orientation, Touching Blocks, and Localisation sub-tests.

"**gr**"=Retrieval capacity or general fluency, ideational and associational fluency which may well play a strong part in scoring well on the Word Production-Categories sub-test.

"**gf**"=Cognitive speed factor, something which, again, the overall fast timing of the CLB tests.

These five factors, says Kline, embrace most of the variance in human ability.[405] Clearly, the family resemblance, although not identical, is close between an IQ test and the CLB. A transformation procedure is possible to derive IQ equivalents from the CLB Z-scores, with 0 equalling 100 on the IQ scores, and +3 equalling approximately an IQ of 148, -3 an IQ of approximately 60 or 70, although this can only be a very approximate measure. The literature certainly seems to suggest that at least the CPQ could be predictive of IQ.

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405 **Ibid**, pp. 28-32.

Procedure

CLB

Art, architecture, music, psychology, mathematics, engineering, and some students from other disciplines aged between 17-50 years were tested in group sessions with the CLB, together with a small number (12 for the categories, 6 for the CLB) of dyslexics. The dyslexics were chosen as the most available and testable variety of the learning disabled. They were contacted by permission of the Scottish Dyslexia Association, and freely volunteered to take part, as did the students. Small payments were made to approximately half the students who took part in the testing. Considerable efforts went into finding comparable numbers of Arts and Sciences students. The bulk of the sessions took place over the last two years, until the CLB **n** had reached 125. Testing sessions were often in groups of over 20, but also some individual sessions took place. All testing was supervised and run by the writer, using the CLB materials already present in the Department of Psychology, together with scoring discs and answer blanks supplied by Professor Harold Gordon in Pittsburgh, who was able to advise on procedure and scoring, both personally and by electronic mail and letter.

Instructions for each sub-test are pre-recorded and played on audio-tape, together with visual examples on 35mm slides where appropriate. The operator must be careful to advance the slides strictly according to the allowed timing for each stimulus. After each period of instruction questions are answered, and rest periods between tests are available if required. The CLB takes between 70 and 80 minutes to administer. The order of testing is:

1) **Serial Sounds**

2) **Localisation**

3) **Serial Numbers**

4) **Orientation**

5) **Word Production-Letters**

6) **Word Production-Categories**

7) **Form Completion**

8) **Touching Blocks**

The answer blanks are placed by the subject into a manila envelope on which they are asked to write whatever personal information is required, such as age and discipline.

Scoring is accomplished by the use of Gordon's IBM compatible scoring disk, which converts raw scores to normed z-scores. Throughout this research the z-scores have been used for analysis.

QUESTIONNAIRE

Subject interviews ran concurrently with the cognitive testing, from which were derived categories by which the data could be analysed. Birth date, sex, hair and eye colour were straightforwardly obtained; no colour chart was used for the latter two characteristics, while for seasonality the year was divided into October to March, inclusive, which was regarded as Winter, and April to September, inclusive, which was regarded as being Summer.

Handedness

Handedness was derived both from a short section within the questionnaire which incorporated elements from those of Annett, Coren and the Edinburgh Handedness Inventory, and from the subjects' stated hand. These were analysed separately. Coren's very simple method of deriving a 'Handedness Score' was used: the questions answered 'Right' were multiplied by 3, the questions answered 'Both (or 'Either')' were multiplied by 2, while those questions answered 'Left' were scored as 1. Individual's handedness was derived from their totals. For example, someone achieving a score of 17-18 would be judged strongly right-handed, while someone with a total of 6-7 would be clearly left-handed. The questions are:
'What hand do you use to write?'
'What hand do you use to hold a hammer?'
'What hand do you use to unscrew a jar or bottle top?'
'What hand do you use to throw a ball?'
'What hand do you use open a box?'
'What hand do you use to catch a ball?'
These questions were judged to be the ones from the lists used by other researchers which seemed to elicit the most meaningful and reliable responses from subjects, and were little different from 50% of those used by Coren.[406]

Discipline was each subject's degree major. These were treated in two ways: one, the stated preferred discipline, and, two, the combination of disciplines into two sorts:-

[406] Coren, S., **The Left-Hander Syndrome: The Causes and Consequences of Left-handedness**, UK.: John Murray, 1992.

those which have mathematics as an essential and foregrounded element, and, simply, those which do not; these were called, respectively, Sciences and Arts. Psychology, mathematics, and engineering students, and a few who were in disciplines such as medicine, business studies, and biochemistry were considered as belonging to the Sciences, while the artists, architects, musicians, and some who were physiotherapists, historians, or studying English literature were included in the Arts. The natural place for the dyslexics seemed in the Artistic category, although they were segregated. Later, the general effects of their removal from the data set were found to be negligible, confined to spectacular performance on one particular sub-test.

The grouping and ordering of the questions structured these interviews in a semi-formal way, ensuring a measure of replicability. Retrospective data elicited from the students was analysed using a qualitative to quantitative method, which was intended to mirror or parallel the overall intention to bridge the apparent gap between the natures of the qualitative artist and the quantitative scientist. Method was therefore intended to exactly fit theme.

Transcripts of taped interviews were examined to judge from the subjects responses whether they had said "Yes" or "No", to the questions asked by the interviewer (the present writer), or whether they had stated one or other of the two preferences offered to them. Those who were deemed to have given ambiguous responses were deleted from that particular category. As a result, the Ns for the various categories vary considerably.

As some of the students who taped interview sessions did not return for the CLB test, and some were equally uncooperative but in the other way, categories and cognitive tests represent two overlapping samples. Some basic data, such as eye and hair colour, sex, hand, birthdate, discipline, and so on were obtained from all students who took part. Category Ns therefore vary from 222 for season to 49 for Need to Draw. Some dyslexics answered the questionnaire by post, not being able to attend for testing because they lived too far from Edinburgh.

The questionnaire was devised to determine from the self-reported developmental and health records of the students and dyslexics characteristics common to the talented individual, including the incidence of such minor pathologies and somatic features as left-handedness, atopic disease, blond hair and blue eyes, speech impediment, myopia and other eye problems, dyslexia, hyperactivity, and a tendency to autism. (see Appendix I for the questions eventually used to devise the categories by which the test scores were divided)

As an illustration of the method adopted, the following report of a pilot study carried out in the first year of the research may be of use.

THE STUDENT ARTIST: A PILOT STUDY INCLUDING A DESCRIPTION OF INTERVIEW METHODS

Interview Preparations And The Interviewer

It was decided at a supervisory meeting that a questionnaire would be needed in order to test for the various factors theorised by the present writer to be associated with artistic ability. As many months had already been spent in reviewing the literature while at Leicester University during the first year of an aborted part-time PhD, the sorts of questions that were necessary to ask subjects were reasonably well-worked out. It was agreed that a pilot scheme should be started in order that the proto-questionnaire could be tested.

It was thought that art students, in particular those studying for the Fine Art degree at both Edinburgh University and the College of Art, would be acceptable to "calibrate" the questions. Some reservations existed about the retrospectivity of the study.

Having contacted Michael Bury of the Fine Art Department, it was arranged that some volunteers should be met on various occasions in order that introductions could be made and some idea given about the nature of the research. Carefully, more mention was made of what it was **not** about, rather than of its actual nature. As an example, to allay fears of possible too-personal prying, any Freudian interest was denied! This served to break any initial tension, as did the very conscious revelation that the researcher had a History of Art degree, and was something of an artist as well. A sense of bonding seemed to be established straight away. Perhaps as a consequence there was little trouble in gaining volunteers. Appointments were made for the sessions at an office in the Department of Psychology, some in the mornings and some in the afternoons, to fit in with the very complex and individual scheduling of each student.

The office was decorated with pencil life studies, detailed pen and ink illustrations of fantasy scenes, and acrylic paintings by the present writer. The intention was to use them as both reference points for some of the questions and to further establish bonding with the subjects. In The interview: a tool of social science, by Eleanor and Nathan Maccoby, it is suggested that interviewers "play" the role which best suits the situation, thus inducing a rapport which ought to encourage better co-operation by the respondents.[407] The interviewer's chair was unfortunately higher than the more comfortable one arranged for them, so giving an impression of authority which was not at all what was intended to be conveyed. The authoritarian textual interpreter, which many commentators have identified as being acceptable to Freud, Foucault and Habermas, is an unacceptable role for the present writer. The intention was to get away from any similarity with the stereotypical psychoanalyst, attempting rather to put into practice a Gadameresque "fusion of horizons". For such a purpose, it would have been better if there could have been an even eye-level with the subjects. Perhaps some of the courses taken as a Doctoral Programme student have over-encouraged the consideration of such philosophical niceties.

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[407] in Lindzey, G. (ed.), **Handbook of Social Psychology**, Vol. 1, Cambridge, Mass.,Addison-Wesley.

The subjects could not see the questions, which were kept on the interviewer's knee and thus upside down in relation to their viewpoint, so preserving an element of surprise. The intention was to prevent them from having any opportunity to prepare their reactions. A fairly large and imposing stereo tape recorder had been provided by the Department, which was placed on the corner of the office desk between the subject and the interviewer, in order that there should be easier use of the two small cylinder microphones, one of which would be clipped to the clothing of the subject. This piece of equipment did not seem to deter or upset the subjects.[408] Cheese crackers and chocolate biscuits were provided, together with a range of drinks, to act as some sort of ongoing reward for the subjects.

It was decided not to make notes during the interviews, but rather to depend wholly on the tapes for a record of salient points. It seemed that some important nuances of the responses could be missed if the interviewer was unnecessarily involved with note-taking, and so lose an opportunity to "dig deeper". The position of the chairs in the office was such that the light from the high windows fell directly on the face of any subject, thus leaving the interviewer's by contrast quite shadowed; it seemed that this might recall in the subject a double cliché, that of both the psychoanalyst and the couch-bound patient **and** the prisoner undergoing the "third degree". However, there was little that could be done to alter the furniture arrangement in such a small room.

In each instance the subjects were invited to come to the main concourse of the Psychology building, where they would be met and guided up to the top floor, where the office is situated. Each one was offered the possibility of free coffee on the way up, from the coffee making facility just off the concourse. Each one was taken upstairs by the most complex route, because of the detour for coffee, a route which almost without exception inspired some remark about labyrinths. It was hoped that any resemblance between the interviewer and the mythical Minotaur would be disregarded. Several remarked on the conclusion of the interviews that they hoped the present writer could guide them out again, because they would be hopelessly lost otherwise. Perhaps the interviewer's Jungian identity had been transformed during the course of the interviews from monster to Ariadne.

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[408] William A. Belson, in Tape recording: its effects on accuracy of response in survey interviews, **Journal of Marketing Research**, 4, August 1967, pp. 253-260; found that tape recording increased the accuracy of reported responses from lower-class respondents, but, with relevance to this sample, reduced the accuracy of reported responses from middle-class and upper-class respondents. Dissonance of assigned word-meaning between class of interviewer and respondent may alter accuracy. It was hoped that the interviewer did not either feel too intimidated by the clearly elevated social status of some of the subjects, or misunderstand their class-specific word usage!

It was found difficult to understand the motivation of the subjects for volunteering for a lengthy session of psyche pummelling. They were very eager to answer questions, especially the females; it was concluded that perhaps such a test was seen by them as exposing their reasons for wanting to become artists, that going over the origins, the initial circumstances which made them what they were, might confirm in their minds the rightness of their choices. Perhaps they hoped that the questions might serve to lessen their self-doubts. Self-doubt and the artist have always been Siamese twins. In that case, perhaps the interviews were of some help. Most said after their interviews that they had been made to think about their art in a new and different way. Such may be the way in which all interviewers and respondents interact, both, as a result, having their opinions and attitudes altered.[409]

The Questionnaire

Overview

Are there any artists, architects, or engineers in your family?

What hand are you?

Are there any left-handers in your family?

Do you or any of your family have a history of allergies?
PROMPT: hay fever, rashes, blisters, swellings?

Are you short-sighted?

Are there any short-sighted individuals in your family?

Are there any individuals in your family who could be called handicapped or retarded?

Do you have any musical ability?

Does any member of your family have musical talent?

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[409] According to Steinkamp, {pp. 487-492, Steinkamp, S.W., Some characteristics of effective interviewers, **Journal of Applied Psychology**, 50, December, 1966} in tests the best interviewers scored significantly higher on dominance, self-confidence and attention to detail, and needed the support of others rather less than most, while increased education and intelligence, high need for achievement, high career orientation, high efficiency in planning, and high manipulative {Machiavellian} test scores correlated together in the profiles of excellent interviewers.{cited in Sudman, S., **Reducing the Cost of Surveys**, Chicago, Aldine Publishing, 1967} Perhaps these are some of the essential characteristics of the ideal PhD researcher, as well.

Do you have mathematical ability?

Does any member of your family have mathematical ability?

Do you have skills in such activities as gymnastics, skiing, tennis, ballet, or swimming?

Does any member of your family have such skills?

Drawing History And Practices

Can you remember how old you were when you first started to draw?

Did your parents keep any of your earliest work?

Did you spend a lot of time drawing?

How old do you think you were when you first made a drawing look like something?

Can you remember the subjects of your earliest drawings?

Did you find you had to draw on the walls, window condensation, exercise book margins and so on when there were no proper materials available?

Did you draw better with one instrument than another?

Did you hold this instrument in a special way?

Do you still hold your drawing instrument that way?

Which hand did you use?

Do you still use that hand to draw with?

Imagery

What subjects did you like drawing as a child?

Where did you find your subjects?

Did you copy them from books, magazines, or photographs?

Did you draw them from real life?

Could you draw some subjects from your head?

Did you "see" a complete, detailed picture in your head when you did this?

If you did, was there any particular way you moved your "mind's eye" over this picture?
PROMPT: Was it a coloured picture?

Can you still do this?

Did such a complete picture make you want to distort or squash your drawings to fit them on the paper?

Or did you let them run off the edge because what was in your head didn't all have to be on the paper?

Would you say your drawing style is "swift and sure", or slow, detailed and deliberate?

Would it be better to say that your drawing style is dictated by what it is you intend to do?

At what point on the drawing surface do you usually begin?
PROMPT: (Indicate drawing on wall) Top left, top right, middle, bottom left...?

Motivation

Since you were first drawing, have there been gaps, when you didn't do much artwork?

Do you still really enjoy painting/drawing?

Could you say art is the only thing you do really well?

Did anyone push you into drawing?
PROMPT: Did you want to please your father or mother?

What emotion do you feel when a drawing has gone really well?
PROMPT: What other emotion is that most like?

Do you always treasure and preserve your work?

Fine And Gross Motor Control

Were you a clumsy child?

Were there any other "physical" things you were good at, such as riding a bicycle, juggling, hand balances and so on?

Are you still good at them?

Can you thread a needle?
PROMPT: First time?

Apart from drawing, would you say you were skilful with your hands in a craft or assembly sense?

Graphic-Painterly Tendency

Did you ever colour your drawings?

Were the colours appropriate?
PROMPT: green for the grass, blue for the sky?

Do you prefer colour or black and white work?

Spatial Ability

Did you have an early understanding of perspective?
PROMPT: In other words, were you able to make an object or a building look solid, or give the illusion of depth or distance in your drawings?

Did you have an early understanding of how to draw people or animals?

Did you have an early understanding of how to draw recognisable portraits?

Could you draw someone in several different positions, as in a swimmer diving from a high board into a swimming pool while doing, say, a pike and a twist?

Have you ever drawn cartoon characters, or superheroes such as Batman or Superman?

Have you what might be called a card-index of figure positions in your head on which you can call, instantly?

Or do you have to work it out on the page?

Narrative Tendency

Did you ever use drawings to make stories around?

Did you ever write a story and then illustrate it?

Abstracting Tendency

Do you doodle a lot?

Do you prefer patterns to realistic art?

Were you always good at reading maps and diagrams or plans?

Did you or do you draw them for fun?

Are you good at pattern tests or puzzles?

Can you read music?

Can you see patterns in mathematical relationships or in melody?

Health And Sociability

Were you often ill as a child?

Were you on your own a great deal as a child?
PROMPT: Because you were ill quite often, or because you wanted to be alone?

Would you say you were a very lively child?

Would you go so far as to say you were hyperactive?

Would you say it was only drawing that made you sit still?

Did you ever live in a world of your own, always daydreaming?

Did other people often have difficulty "getting through" to you?

Was there a time when you really didn't like other people?

Do you still feel like that?

Do you sometimes feel that life does not make much sense?

Did it seem like that to you as a child?

Were you early or late learning how to speak?
PROMPT: Has anyone mentioned this to you?

Were you early or late in learning how to read or write?
PROMPT: Has anyone mentioned this to you?

Were you early or late in learning how to walk?
PROMPT: Has anyone mentioned this to you?

Check Questions

At what age do you think your drawings became exceptional?

Before five years?

Before ten years?

After?

The Subjects

The data below relates to seven subjects, three males and four females. There were eventually a total of ten from Fine Art, five males and five females. Subsequently, the questionnaire was administered to five males and five females from the Department of Architecture, followed by a third group drawn from maths students. These were then be compared with a control group from Psychology. In addition to the information required in the questionnaire, it became of interest, as a result of further reading, to know their birth dates, and to estimate as accurately as possible their eye colour and true hair colour. The Fine Art Department were co-operative in supplying essay marks and slide test marks, thus enabling a judgement to be made via some sort of objective assessment of both facility with the written word and powers of visual memory. The **difference** between these two sets of marks might enable a judgement to be made on their respective cognitive profiles, whether they tended to be more or less strongly lateralised in ability. Facility with the written word is recognised as a left cerebral hemisphere talent, while visual memory may be a right hemisphere function. To further this approach, the College of Art had supplied tutors' assessments of graphic versus painterly tendencies. It was carefully explained to all the subjects that any information obtained concerning them would be in confidence, and if published in any way would be anonymous. The information concerning some of these individuals that follows has been carefully edited and altered to accord with those conditions.

Subject A was born in June and had reddish-fair hair and blue eyes. He was immediately at ease, spoke clearly and fluently. As with all the subjects, the interview lasted well in excess of an hour. The answers were given with little hesitation and appeared to be honest and straightforward. He gave the impression of being a pleasant and outgoing person, certainly much more open in his answers than might have been expected when talking to a stranger. He is a Second Year, academically ranking fourth out of the seven, but first by the Slide Test criterion. He was estimated to be evenly balanced between the Graphic and Painterly poles by his tutor at the Edinburgh College of Art.

Subject B was born in May and had brown hair and hazel eyes. She was immediately at ease and bursting to talk, which she did fluently and at length. However, her answers to two questions regarding childhood or youthful illness contradicted each other. One and a half years of serious illness identified near the beginning of the interview had "disappeared" when a check question was asked nearer the end. This may indicate some second thoughts about excessive honesty. It was known that she had been seeing a counsellor while at Edinburgh; she may have regretted an answer which confirmed a history of psychological disturbance. A Second Year, she ranked seventh and last academically (which may have been a result of the dyslexic tendency mentioned in her responses) and fourth out of the five for whom there was a Slide Test rating. Again, her College tutor estimated that she was of equal ability between the Graphic and Painterly poles.

Subject C was born in May and had brown eyes and black hair. He was far less at ease initially, even though he had attended life drawing classes with the present writer in the evenings during the first term of the academic year 87/88, had spoken often and in a friendly fashion. Some sort of personality change appeared to have taken place since then, with a marked reduction in confidence and increase in depressive characteristics. Blame did not seem to lie with the interview surroundings, nor with the interviewer, although, of course, these are possible reasons. Later in the interview, in a deeply felt answer, he was to reveal that his motivation for wanting to become an artist was in finding a voice for himself, one that represented his special and perhaps superior self. His aim was, through art, to eliminate self-doubt and self-criticism. The interviewer was not able, in the role of pseudo-conversationalist, to point out the hopeless idealism of this aim. He and his brother were adopted by an apparently well-travelled and wealthy family, steeped in the arts; this rather privileged background seems not to have protected him from feelings of insecurity, perhaps stemming from his adoptive status. As in the case of Subject B, Subject C seems to have reacted unfavourably to the pressures, especially peer-pressures, of University life. He tries to give the impression that other people and their opinions matter little. This is clearly a "front" for a very sensitive and rather worried young person, who perhaps fears that Edinburgh may prove too much for him. Having struggled through this, his First Year, his Second Year ought to restore his confidence. Academically, he ranks first of the seven, with his Art College tutor perceiving a decided leaning toward the Painterly pole.

Subject D was born in July and had blue eyes and blond hair. He was a friend of Subject C, both volunteering together, as had Subjects A and B. Their friendship appeared significant, Subject D having a speech impediment due to a hare lip and cleft palate, now surgically alleviated. Both, for their different reasons, seemed to be "outsiders" in University society, and it would seem likely that they might have joined forces against the rest. Youth peer-groups are sometimes very cruel with those who do not conform; it is the "green monkey" syndrome. In addition to any physical disability, he said that his vocabulary was quite restricted; he admitted strong feelings of frustration at not being able to fully express himself. This subject was most interesting , because he possessed a certain pattern of factors that several theorists have claimed are often to be found in the artistically talented (Geschwind and Galaburda theory, etc.). Ranked sixth academically, this First Year was estimated by his Art tutor to be equidistant between the Graphic and Painterly poles.

Subject E was born in December, and had mid-brown hair and blue-green eyes. She was pleasant and fluent in her answers, apparently co-operating fully. She admitted after the interview that it had been an unexpectedly exhausting experience. She is of above average height (5' 7" at age 12), and had a skin problem which might denote hormone imbalance. A Second Year, she was ranked fifth academically, and was second overall in the Slide Test. Her Art tutor considered her to have definite leanings toward the Graphic pole.

Subject F was born in August and had light brown-to-fair hair and blue/grey eyes. She gave the impression of being quieter and more introspective than the others, more of a "loner" (she said that as a child she had often preferred the company of her cat to other people, and used to conduct long conversations with herself). She was slightly less fluent than the others, although seemingly with just as much interest in answering the questions as fully as possible. Third academically, she was third on the Slide Test, as well. A sculptor, she was judged by her tutor to be equally balanced between Graphic and what was termed "Sculpture/Creative" areas, which might be equated with "Painterly".

Subject G was born in May and had mid-brown hair and blue eyes. She said that, without exception, all her family have blue eyes. She was clearer and more forceful in her speech than Subject F, although she gave the impression of a certain analytical coldness in her approach, a more aloof and withdrawn personality. She possessed some obvious excess facial hair, which could indicate hormonal imbalance. Second overall academically, she was fifth in the Slide Test rankings, while her Art tutor thought she was apparently stronger in the Painterly area.

Transcription Method-Theory And Problems

In an effort to proceed according both to the method taught in the Qualitative Research course of the Doctoral Programme at Edinburgh University, and to that outlined in A.N. Oppenheim's **Questionnaire Design and Attitude Measurement**,[410] firstly, sheets of paper had the names of the subjects written down the left-hand side in the order in which the interviews had taken place, to preserve the chronology. Each page had headings across the top representing the questions in the questionnaire, perhaps three or four per page. The tapes were played in the correct order, and notes were made under each heading and from left to right for each subject. Sections on this initial notation were open-ended, growing or shrinking with the interest of the particular response. Some verbatim quotes were made, although most attention was paid to whether or not the information gained had relevance to the factor which had inspired the question in the questionnaire. As Oppenheim and others have noted, it is at this stage of the proceedings when information is lost; the researcher's judgement must be alert enough to prevent it being relevant information. As Dr McGlew, the course tutor, recommended, "quotable quotes" were transcribed exactly. Most replies were to the point, although rarely short: Arts students always seem to be able to say the same thing in several different ways and at length.

The types of error committed by the interviewer were doubtless many: in transcription, there were detected missed questions, irrelevant answers, lack of sufficient detail, and superfluous questions, errors which will be eliminated with practice. Indeed, the purpose of the pilot-study, ideally, is to eliminate not only the questions which have no meaning to the subjects, those others which fail to address themselves to the areas of greatest interest, but also to eliminate errors in interviewing technique.[411] Inevitably, further reading has generated other questions to include in the questionnaire; however, this is something which cannot be done, now the interviews have commenced.

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[410] Oppenheim, A.N., **Questionnaire Design and Attitude Measurement**, Heinemann Educational Books, pp227-248, 1966

[411] It was noted that the interviewer had an appalling tendency in the early tapes to give vent to a high pitched, nervous laugh. Later tapes are evidence that this probably disconcerting bray has now been brought under control. As well, several pointless questions have been dropped.

Some questions, despite the extended answers, could be turned into closed ones, reducing the excess verbiage to straight "yes" or "no", or on a scale of "more" or "less". However, this could not be done with most of the questions, those which invited the giving of information, and so could be termed open. It was in these that interesting responses were often followed-up, supplementary questions being asked which were intended to elicit greater detail, or moving into branching areas. Later, sections or "dividers" may be inserted into these heterogeneous chunks of information to make it possible for them to be turned into more quantifiable statements. This would depend on how often the respondents gave information in exactly the same areas in these open questions. It seems that, fortunately, almost wholly instinctual minor prompts within the open areas for the first two or three tapes later became habitual, producing a gratifying uniformity of response. The reasonably uniform backgrounds of these, on the whole, quite privileged individuals, would tend to increase the likelihood of similarity of response in areas of upbringing and schooling, hobbies, sports, experience of other countries, and many other shared aspects of experience. Some researchers have concluded that open questions should be used as sparingly as possible, because word-choice in the slight variants of the questions used biases responses. There is little which can be done when interviewer idiosyncrasies contaminate the data, except follow the advice of the Greeks and know thyself.

In accordance with the techniques recommended by Dr McGlew and others, the interviewer nodded, uttered encouraging noises, parroted the last significant word of the preceding response, or maintained a silent and yet expectant attitude in order to tease out amplifications of interesting statements by the subjects. The role as pseudo-conversationalist, one who **seems** to be having a conversation with the subject, but, in fact, is doing something very different, was maintained quite well, apparently, although many times there was the temptation to respond naturally. Some questions were extended, when it was believed the subject needed a less controlled, more 'fallible' approach. Researchers have found that there is some evidence that the longer an interviewer speaks, the more the respondent will say in reply, although others have warned of the effect of complexity, where a question becomes more sensitive to wording.[412]

One of the few criticisms possible of an example tape recording of an interview played to the student group of Dr McGlew was that, however highly regarded the interviewer was, some of the questions she asked the respondent were delivered in a noticeably mechanical and formal fashion. It sounded very much as though she were reading them for the hundredth time that week; for the apparently cheerful and out-going young mother being questioned this seemed to be acceptable, nevertheless, it could be imagined that such a delivery could be less effective with a quieter, more withdrawn individual. The lack of emotional light-

412 in Payne, S.L.B., **The Art of Asking Questions**, Princeton, Princeton University Press, 1951.

and-shade in a vocal tone is irritating to many. Psychologists would expect it to be most irritating of all to females, who are especially sensitive to sound and emotional vocal overtones. In the interviews the determination was not to fall into a mechanical drone, always injecting an element of warmth and interest into the voice asking the questions. By so doing, of course, the risk was run of sounding more like a double-glazing salesman or a chat-show host than a psychologist; sounding insincere appears to be an occupational hazard for all three. Fortunately, there was a real and strong interest in both the students and their responses to the questionnaire; little simulation of sincerity was needed.

A further problem, and one as unavoidable, is that the sample had been heavily pre-selected in different ways:

They were volunteers, and so differ from other students by virtue of whatever it is in a person that makes them volunteer for anything. (The subjects pointed out that the present writer had "...got all the big-mouths in the Department"! It may be that the cause of the research may have been better served by speaking instead to those who were **not** "big-mouths".)

As regards intelligence, most of the variance in the group of subjects, in a statistical sense, had been removed by the long series of academic tests which all of them had had to undergo simply in order to become University students.

Being Fine Arts students, they must surely have encountered artistic creativity questions before and so were unlikely to have been naive, the "unsullied sources" most researchers seem to assume their subjects to be.

Perceived as a tutor, of sorts, the interviewer may well have encouraged in them a desire to please, to give what they believed was wanted. Just what those beliefs might have been, and how they varied, subject to subject, there was, of course, no way of knowing.

Given all of the above, and the structured nature of the questions and interviews, a good measure of uniformity of response was to be expected.

An obvious way of sub-grouping the responses was by gender; in addition, the theory central to this research demands comparisons of response between males and females in certain areas; possible differences would tend to support that theory. The main aim, however, was to discover links, significant correlations between characteristics. To do this, it would be necessary to compare the various responses with a degree of expectation as to what should be found in the way of associations. It is essential not to be too full of *a priori* categories and rigid ideas, nevertheless, the perceptions of the researcher are inevitably led by theory and personal bias. The semi-structured nature of the questionnaire provides a much narrower gauge "net" with which to trawl the facts than does a grounded theory approach, where, to some extent the gauge of the net is dictated by the responses of the subjects. However sensitively fishing is carried out, some potentially valuable information may not get through the net. The use of the term "net" in this instance is not solely to provide a suitable pictorial analogy, but refers to Cronbach and Meehl's conception of a nomological net or network, where observable properties or quantities are related to each other, or theoretical constructs are related to observables, or different theoretical constructs are related to each other, to create either statistical or deterministic laws which interlock in a theory.[413] In the early stages of a network the construct is simple and has few connections; the aim of the questionnaire is to confirm or disconfirm those connections thought to have been perceived, and perhaps to discover others. Cronbach and Meehl state:

> An enrichment of the net such as adding a construct or a relation to theory is justified if it generates nomologicals that are confirmed by observation or if it reduces the number of nomologicals required to predict the same observations. When observations will not fit into the network as it stands, the scientist has a certain freedom in selecting where to modify the network...there may be alternative constructs or ways of organising the net which for the time being are equally defensible.[414]

In this, it is possible to take them to mean that it is in order to adjust the present questionnaire/theory as it is used, to obtain a better fit with the observed facts, under the guiding principle of parsimony. They continue by saying: "As research proceeds, the construct sends out roots in many directions, which attach it to more and more facts or other constructs".[415] Indeed, this is how the theory appears to have grown, and is the reason why the questionnaire contains so many factors for which there must be information, all of which it is possible to believe are interrelated.

More information is lost in the next stage of transcription, in which are used squared-up sheets of paper, where the spaces allocated for the responses are of equal size. The initial record of responses is gone through, core facts extracted from that and entered in the new set of sheets. In the same way that a radio signal loses information content the more times it is put through a series of reproductory transformations, the responses on the tapes lose a proportion of their "real world" status each time another reproductory transformation is carried out, subjectivity of reaction and consequent choice of material to record increasing the theoretical component of the overall results. At this stage, a preliminary, and necessarily incomplete, analysis is carried out.

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413 Cronbach, L.J., and Meehl, P.E., Construct validity in psychological tests, **Psychological Bulletin**, pp. 281-302, 52, 1955.
414 **Ibid.**
415 **Ibid.**

Data Analysis

Three of the seven were born in May; this is not especially meaningful for the theory, certainly with such a small sample, although it is a move in the predicted direction. Of greater interest was the fact that five of the seven had predominantly blue eyes, while lighter coloured hair seemed to predominate, as well. These will be factors looked at in the larger, final sample. In their answers, the subjects revealed that actors, artists, sculptors, engineers, and architects figured frequently as close relatives, while the females were all strongly right-handed, with the males far less so. Asthma, hay fever, allergies to ivy, cat hair, dogs, horse hair, honey, grass, and house dust, together with eczema and sinus disease may be found in either the subjects or their close relatives. The top three academically were the only ones to have myopia, while those with perfect sight, appropriately enough, registered the best scores on the Slide Tests, which are primarily tests of visual memory. The person with the most imperfect sight had the greatest difference between her academic and visual memory test scores.

Hyperactivity, neural tube defect, and dyslexia were to be found either in these subjects or their close relatives in three out of the seven, while hereditary disease and mental disorders figure in the histories of two more. Mathematical skill figured often in their range of abilities, with all, obviously, having GCE "O" Level, but three having either a Higher or "A" Level, two claiming it was their best subject at school.

Of the two out of the seven who admitted to having poor gross motor control skills, one said that she was always breaking things as a child, and was strongly right handed, myopic, and astigmatic, while the other was the female who had been a very tall adolescent with what may be a continuing hormone imbalance. Six of the seven claimed to be able to thread a needle first time, while the tall female admitted only adequate competence, although she enjoys sewing. The only sculptor and the only asthmatic amongst the seven, as well, was the only one who, as a child, held her drawing instruments in an abnormal fashion, and even today holds her knife and fork in her fists with her elbows turned outwards.

Five of the seven were artistically active before the age of five, four were similarly active at between three-and-a-half and four years; most seemed to be recognised as having possessed early skill, and so were encouraged, but **not** pushed, to develop what abilities they had. Four out of the seven claimed to have a reasonably clear image of what they wanted to paint or draw appear in their mind's-eye on demand, although apparently not being able to call upon any "card-index" of figural poses to deal with any possible attitude of required staffage in compositions.

Six out of the seven were forced to admit that art was probably the only thing that they did really well now, other possibilities having been discarded, perhaps because art had become the most important activity in their lives. This may be self-justificatory, as they may have had less choice than they imagine. The seventh stated very clearly that she was an all-round able person, and did **not** intend to take up art as a career. The motivation for doing well at art varied enormously: one of the subjects admitted to feeling pleased but not allowing others to see this; another found that it aided his sense of superiority and self-identity; yet another felt reassured by a good piece of work, in the sense that he felt he might yet stand comparison with the greatest artists in history, if he continued to work at it! A female stated that she got a "sexual buzz" out of producing a good piece of work, and felt that all was right with the world for up to two weeks after such an experience; another felt intensely happy, yet not self-satisfied, knowing that there was still a long way to go in her art; the last expressed the same caution, while admitting that she felt great, if temporary pride, and a desire to show her work off to others.

From their responses, the three males clearly tended to prefer linear forms and low colour tones, which even a quite long artistic education had failed to translate into a love for colour, as might have been expected. In contrast, all the females expressed a strong preference for rich and saturated colour. Unfortunately, these responses are opposed to some extent by the estimations of their tutors: while two of the males are seen as having shown equidistance between the Graphic and Painterly poles, and a third clearly identified as being more in the area of the Painterly, the females include one, the tall, clumsy individual, who has a stronger performance in the Graphics area. Most discard works considered below standard, except for the myopic academic, who keeps all of her work! All expressed, quite strongly, a lack of understanding of perspective, and showed an evident dislike for it as a discipline (this may prove to be one of the major differences between the Fine Art and the Architecture students). Only the tall female considered herself to be good at portraiture, while the other six said they were either not interested, or disliked "face-painting". Four out of the seven used their art to tell stories, seemingly having therefore a narrative tendency, although none tried to illustrate anything they had written. All doodled, some quite compulsively, and six out of the seven said that they were attracted to patterns in art. All claimed skill with map or diagram reading, while five out of the seven used to draw them for fun, as well.

Six out of the seven said they were very happy to be on their own, enjoying their own company, the seventh, who expressed the opposite preference, being the only one with a history of psychological disturbance and consequent counselling. Only the asthmatic, myopic academic female, and the blond male with the harelip said that they were within any sort of definition of hyperactivity as a child, although three others admitted to having been extremely lively. Six out of the seven said that they daydreamed a very great deal, sometimes to the extent that they totally lose track of where they are. Four out of the seven said that other people often had difficulty communicating with them, while an overlapping four admitted often not wanting to have anything to do with other people; there does seem to be a fairly strong sense of isolation about the group members generally. Most uttered their first words at a normal or average age; however, the tall, clumsy female was speaking fluently at quite an early age, and writing at four years, although, as might have been expected from her apparent continuing lack of gross motor control development, she was a late walker. The asthmatic sculptress was an equally early reader and writer, and an equally late walker. Six out of the seven were recognised by observers beyond the family circle as being exceptional artists before the age of ten, and three were recognised as such before the age of five.

Conclusion

All these suggestive connections, possibly fruitful parallels, and seemingly meaningful confirmations of predictions based on the theories under investigation, will have to remain fragmentary and "not proven" until the sample enlarges, and a full and statistical analysis can be carried out on the data. As they stand so far, the results of the questioning have been encouraging, and invite a lot more work in the same direction. After the pilot study has been completed and the questionnaire fully adjusted through sensitive reaction to what has been learned, there may be not only a better understanding of both the physiological and psychological nature of the student artist, but also a more useful research tool with which to find out much more about the roots of artistic behaviour.

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At that point the pilot study preliminary report concluded. It is interesting to note how many of the variables recognised at that early stage later developed into full-blown analytical categories. From such a beginning the research enlarged and became more cognitive and experimental in nature in the subsequent four years.

The statistical analysis mentioned in the pilot study report was indeed carried out, using the "Statview" package on the Apple Mac microcomputer, and included Chi-Square tests, Factor Analysis, unpaired one-tailed t-tests, non-parametric correlations, multiple regressions, and analysis of variance.

REACTION TIME TESTS

In experiments involving up to 113 male and female undergraduates from various Departments of the University of Edinburgh, two tests of choice reaction time were given: the Sternberg (1966) memory scanning program,[416] and the McCarthy and Donchin (1981) choice reaction time test, both presented on BBC microcomputers with two-button choice boxes attached. The Sternberg varied memory "bit" size with response decision, and the McCarthy and Donchin varied ease of word recognition with response decision, both tasks using a within-subjects design. Subjects were tested individually in cubicles in the Department of Psychology.

STERNBERG:

This consisted of a visual stimulus (two inward-pointing arrow-heads) to help subjects attend to the screen, followed by a string of numbers shown consecutively. Each memory set ran between 1 and 6 digits, randomly chosen from the range 1-9; these were presented at the average rate of 1.2 seconds each; 2 seconds retention time was allowed, then after each set a cue tone sounded and a probe or target digit appeared on the computer screen. Subjects then had to decide whether or not the target number had appeared in the previous set and respond accordingly (YES or NO). Timing started from the moment that the probe appeared, terminated by the subject pressing one of the two response-box buttons. There were 120 trials, with 24 practice trials at the beginning and regular test periods. Reaction times were recorded to the nearest millisecond, the subjects having been asked to complete the tasks quickly but accurately.

MCCARTHY AND DONCHIN:

There were 64 trials, presented in blocks of 16 to allow resting time, preceded by a practice trial. The cue word "same" or "opposite" was displayed on the screen centre for approximately one second, then a 6x4 matrix containing the target words "left" or "right" was displayed. The matrix could take two forms: the first made up of "hash" signs, the second being made up of random letters of the English alphabet. Subject responses were determined by the cue word as well as by the target word. If the cue word was "same", the button which should be pressed is that which is the same as the target word; if the cue word was "opposite", the opposite button to the target word must be pressed. Cue, matrix type, and position of stimulus were randomly selected for each trial. The two variables varied were the discriminability of the stimulus word (LEFT or RIGHT), in which "hash" signs were high and letters were low discriminability conditions, and the compatibility of the stimulus with the button to be pressed on the box. For example, the right button would be pressed if either SAME was succeeded by RIGHT or OPPOSITE was succeeded by LEFT.
Testing was conducted under the present writer's supervision during the 1991 weekly laboratory classes in the Department of Psychology. Eye colour and sex for each subject was noted.

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[416] Sternberg, S., High-speed scanning in human memory, **Science**, 153, 652-654, 1966.

RESULTS

ANALYSIS: INFERENTIAL STATISTICS

All general Summary statistics for Hand Score, Reaction Time, and the Cognitive Laterality Battery will be found in table form in **Appendix III**; however, initially a Factor Analysis of the whole sample data will be examined in comparison with Gordon's original (1986) Factor Analysis which provided support for his claim that the eight sub-tests belong to two different factors, four verbal-sequential and four visual-spatial. The intention will be to show that this sample does not differ from the U.S.A. sample in its Factor Structure.

Significant associations by Chi-Square tests found among the Categories derived from the interviews grouped the individuals who answered the questionnaire. These groupings and associations were taken as the starting point for the statistical analysis of all the data from the different components of the CLB. Due notice was taken, as well, of those CPQ scores which significantly divided the tested individuals into two large groups, or, in other words, showed discriminability. The relevance of these associations and differences to the hypotheses already stated is noted.

The variables will be divided into sections: 1) Somatic Associations; 2) Psychological Associations; 3) Cross Associations (between the variables in the first two sections). In each instance, the Chi-Squares will be reported first; the non-parametric analysis results, being by their nature more conservative, less sensitive, will form the template for the parametric analysis. Regressions will be reported where they are deemed of interest, in order that those variables which contribute significantly to the variance of the categories and CLB scoring can be isolated, together with identification of the strength of their contribution. Regressions will be primarily used in the Cross-Associations section. Detailing of the CLB data pertaining to those categories will follow, in order that the links between category data and z-score CLB data should be clarified. These will be in the form of one-tailed Unpaired t-tests (all hypotheses are unidirectional). ANOVAs will be used, as well, to check all the important variables against each other, as measured by the z-scores. The following results section will be an analysis of the sub-groups Artist, Mathematician, Musician, and Dyslexic, using ANOVA and Factor Analysis, seeking the ways in which their mean scores on the different tests making up the Cognitive Laterality Battery reveal associations and differences between them.

The difference found by Levy in 1970 in her PhD thesis[417] between the Wechsler Intelligence Test Verbal and Performance scores of left-handed students as compared to right-handed students was thought likely to be repeated in a comparison between Propositional and Appositional scores of the left-handers as compared to the right-

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[417] Levy, J., Information Processing and Higher Psychological Functions in the Disconnected Hemispheres of Human Commisurotomy Patients, PhD Thesis, California Institute of Technology, 84-90, 1970.

handers in the undergraduate sample examined here. Accordingly, the fifth section reports that comparison.

FACTOR ANALYTIC STRUCTURE COMPARISON WITH GORDON'S U.S.A. SAMPLE

75% of the 251 adults in Gordon's 1986 sample were college students, compared with something like 99% of this sample. The age range was greater in the Pittsburgh sample, going from 20 to 60, while this sample goes from 17 to 50 years. As with the Pittsburgh sample, it is recognised that this is not a true, randomly-selected subject set, so all conclusions may only be drawn to others of this sort.

As for Gordon, for this sample a Principal Component Analysis was carried out, and, similarly, only roots greater than one were used; the Transformation was Orthotron/Varimax, too. He found that the eigenvalues for his sample were two, one giving 2.92 and the other 1.49, accounting for 36.5% and 18.6% of the variance respectively. For this sample, the corresponding figures were 2.608 and 1.433, giving 32.6% and 17.9% of the variance. As with his analysis, there were two other eigenvalues, each of which accounting for a further 10% or so. Where the samples differed somewhat was in the communality figures: Gordon had the two verbal fluency tests as those with the highest communality, followed by Touching Blocks and Orientation; this sample has the Orientation test scoring highest on communality, followed by Touching Blocks, and then Form Completion and Word Production-Categories. For Gordon, Form Completion had the least communality.
The Pittsburgh sample produced two factors, as did this one, which were identified with the left and right cerebral hemispheres and their usual functions, typified as, respectively, Propositional thinking and Appositional thinking (**TABLE SEVEN**).

SUB-TEST	Factor one P	Factor two A
SERIAL SOUNDS	.494	.333
SERIAL NUMBERS	.484	.155
WORD PRODUCTION-LETTERS	.826	.022
WORD PRODUCTION-CATEGORIES	.731	.134
LOCALISATION	.187	-.390
3D ROTATION-ORIENTATION	.065	.760
FORM COMPLETION	.296	.319
TOUCHING BLOCKS	.098	.796

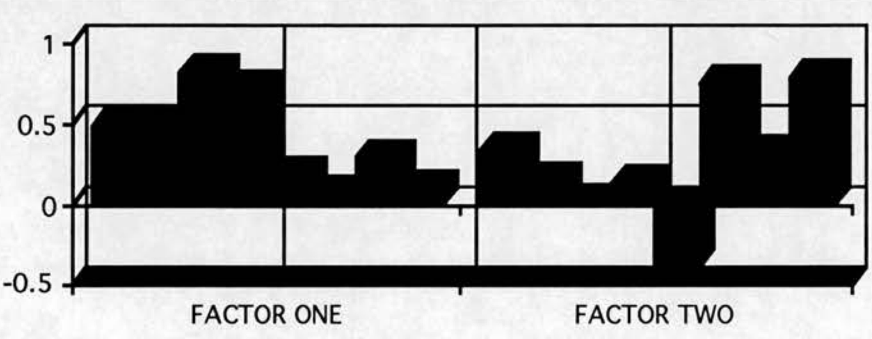


TABLE /GRAPH SEVEN : CLB FACTOR ANALYSIS-U.S.A. ADULTS TESTS

It may be noted that Localisation has minus values, indicating that Gordon used the raw scores for his adult analysis, although elsewhere he uses the z-scores; the raw scores for this test increase as scoring worsens, unlike all the others. It is uncertain which of many rotations Gordon chose to report, although he states it was a Varimax. Bearing in mind the size of the values quoted, it does not seem to have been the final Factor Score Weights of most statistics packages, but rather the straightforward Orthogonal Transformation Solution-Varimax. Accordingly, the following (**TABLE/GRAPH EIGHT**) is the equivalent for this sample:

	Factor one	**Factor two**
SUB-TEST	P	A
SER. SOUNDS	.684	.185
SER. NUMBERS	.600	-.085
WORD PROD.-L	689	.244
WORD PROD.-C	.725	.054
LOCALISATION	.284	.549
3D ROTATION-ORIENTATION	.076	.773
FORM COMPL.	-.053	.714
TOUCH. BLOCKS	.107	.757

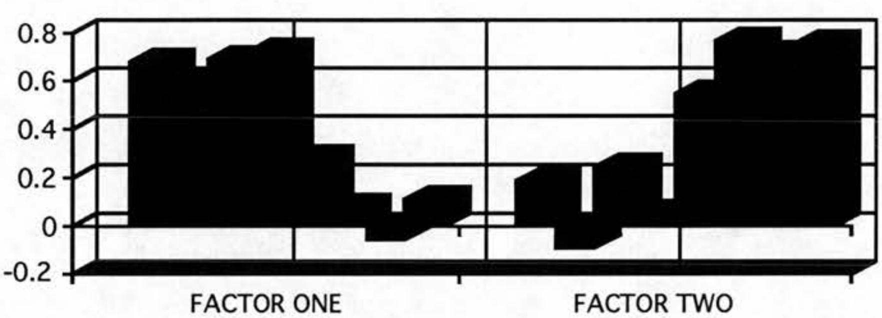


TABLE /GRAPH EIGHT: CLB FACTOR S-UK ADULTS

The negative loadings seen in both Serial Number's A Factor and in Form Completion's P Factor are genuine negative loadings, unlike Gordon's. While the Pittsburgh sample had almost equal loadings on the two Factors for Form Completion, the UK. sample has a most unambiguous loading on the Appositional Factor. Conversely, while the U.S.A. sample showed clear Appositional loading for Localisation, the UK. sample was less clear. Generally, however, the values were comparable, and the patterns of loading were very similar, clearly showing that the four verbal-sequential tests measure something rather different to that measured by the four visual-spatial tests [**FIGURE FOUR**], and which may be identified with the two ways of thinking called Propositional and Appositional after Bogen (1969) and Hughlings Jackson (1874).

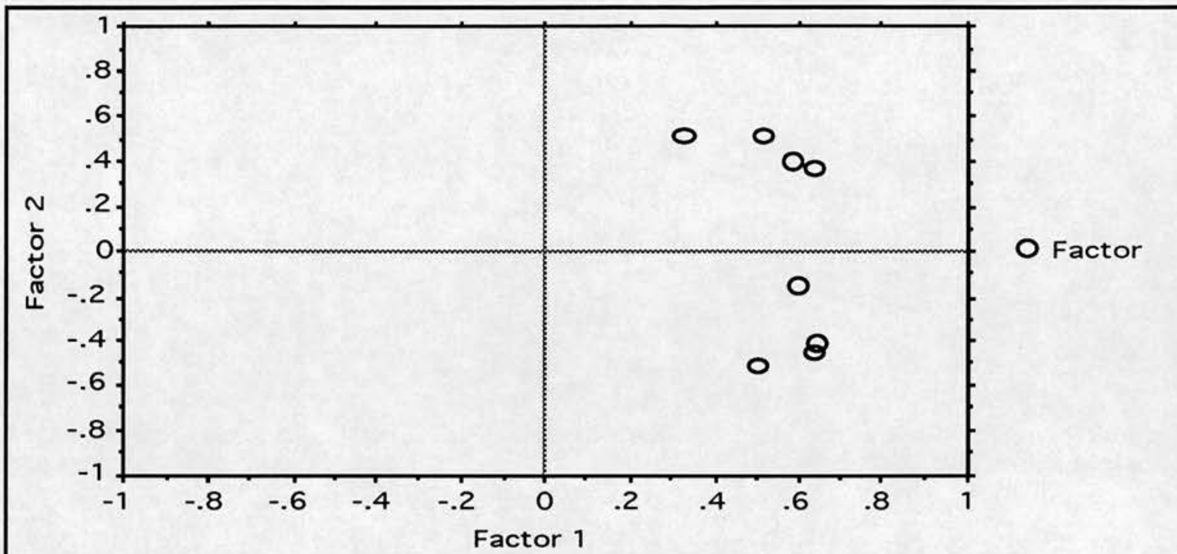


FIGURE FOUR: FACTORS PRODUCED BY UK CLB SAMPLE

Accordingly, both the Pittsburgh and Edinburgh samples can be considered closely alike for the purpose of this study.

CONSTITUTIONAL OR PATHOLOGICAL SOMATIC VARIABLES

Clumsiness, Eye and Hair Colour, Late Winter Birth, Child Illness: High/Low CPQ Groups

The categories derived from the interviews and postal interview schedules provided evidence for features associated with those measured as the top 30 scorers on the Cognitive Performance Quotient of Gordon's CLB and associations with the bottom 30 scorers. It was hypothesised that different somatic characteristics would typify individuals grouped in the two sets of 30, and that the bottom 30 would contain more of those classified as likely to be at risk from mild pathology, as suggested by the Geschwind-Galaburda theory. High versus Low CPQ was thought to be a prime guide to identification of associations of characteristics, and so was analysed in great detail. Two somatic characteristics were found to be significantly associated with scores in the bottom 30: clumsiness, and light eye colour [**TABLE NINE**].

N	df	Phi	Chi-square	prob.	variable
28	1	.549	6.039	p<.02	clumsiness
56	1	.372	6.319	p<.02	eye colour

TABLE NINE: ASSOCIATION WITH HIGH/LOW CPQ SCORING GROUPS

76.19% of those who declared themselves never to have been clumsy were in the High 30, while 54.55% of the Low 30 had said they were clumsy. Only 5.88% of the High 30 reported themselves clumsy. 29% of the variance in one variable could be explained by the other. 75% of the dark-eyed were to be found in the High 30, while only 37.5% of the light-eyed scored that well. The light-eyed made up 76.9% of the Low 30, and only 40%

of the High. There seems to have been a significant clustering of light eyes in the Low and of the dark eyes in the High 30.

60% of the Low 30 were Late Winter Birth, while only 23.53% of this birth period were to be found in the High 30. As a contrast, 68.42% of the individuals born outside these months were high scorers; 69.23% of the winterborn were to be found in the Low scoring section. The Chi-square was not significant, however (N=32, df=1, Phi=.371, Chi-square=3.012, p.0826), so no real grounds may be found for assuming that being born in the winter and spring (and therefore possibly having a greater chance of developing schizophrenia) is associated with low test scoring.

COGNITIVE LATERALITY BATTERY-ALL SCORES

When the test scores for the CLB on all normal subjects are examined there are clear and significant differences between scores on some of the sub-tests by those who declared themselves to be clumsy or not, and also light-eyed and dark-eyed individuals. First of all, clumsiness will be considered, using an ANOVA (analysis of variance) and following with t-tests on individual sub-tests of the CLB [**FIGURE FIVE** and **TABLE ELEVEN**]:

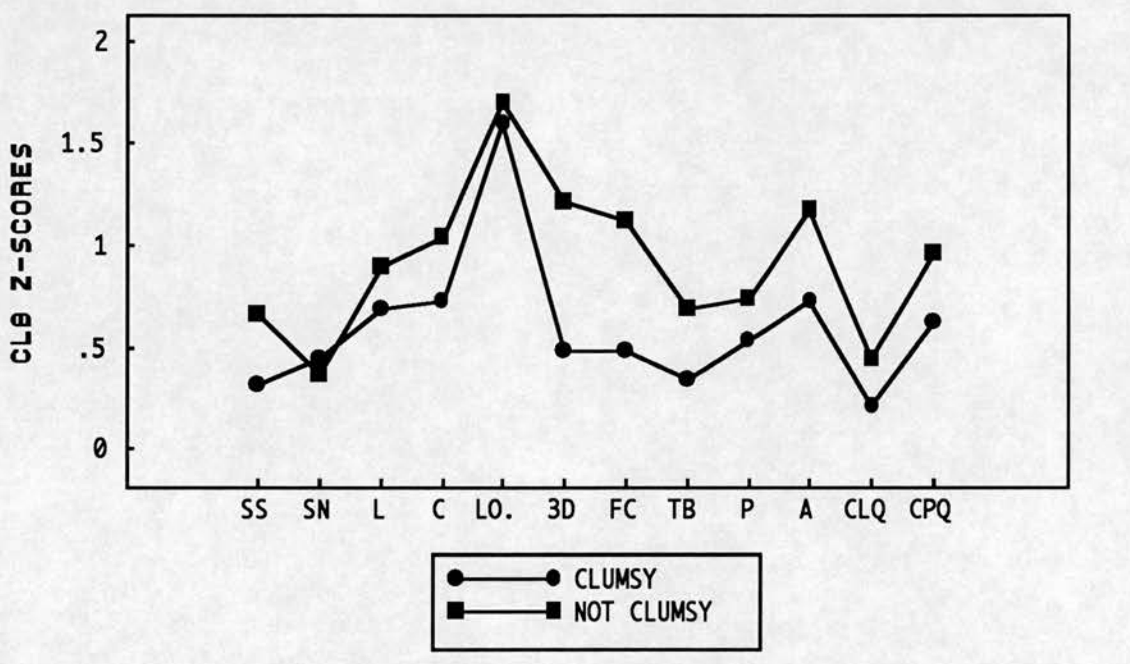


FIGURE FIVE: COMPARISON OF CLUMSY / NOT CLUMSY GROUPS CLB SCORES

Figure Five clearly shows the overall cognitive advantage, as measured by the CLB, possessed by the not clumsy over the clumsy. An ANOVA on the CPQ scores alone proved non-significant, although only marginally [**TABLE TEN**]:

CPQ-Cognitive scores				
Analysis of Variance Table				
Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	1.293	1.293	3.433
Within groups	53	19.971	.377	p = .0695
Total	54	21.265		

TABLE TEN: ANOVA ON CPQ SCORES FOR CLUMSY/NOT CLUMSY GROUPS

Because the ANOVA was so close to significance, the scores were examined in detail by t-tests; the following was shown [**TABLE ELEVEN**]:

3d Rotation				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
53	-2.734	.0042		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	17	.470	.817	.198
NO	38	1.205	.156	.963
Form Completion				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
53	-2.453	.0088		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	17	.469	.823	.2
NO	38	1.102	.148	.911
Touching Blocks				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
53	-1.749	.043		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	17	.330	.782	.19
NO	38	.678	.634	.103
Appositional score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
53	-2.288	.0131		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	17	.710	.649	.157
NO	38	1.165	.695	.113
CPQ-cognitive score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
53	-1.853	.0347		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	17	.616	.491	.119
NO	38	.948	.66	.107

TABLE ELEVEN: CLUMSY/NON-CLUMSY GROUPS CLB SCORES-T-TESTS

As may be seen, those who acknowledged being both clumsy in childhood and in the present showed significantly lower scoring (values underlined) on three of the Appositional sub-tests, the greatest effect showing in the 3d Rotation sub-test [**FIGURE SIX**], the combined effects of which, not surprisingly, produced a significant difference on the Appositional score.

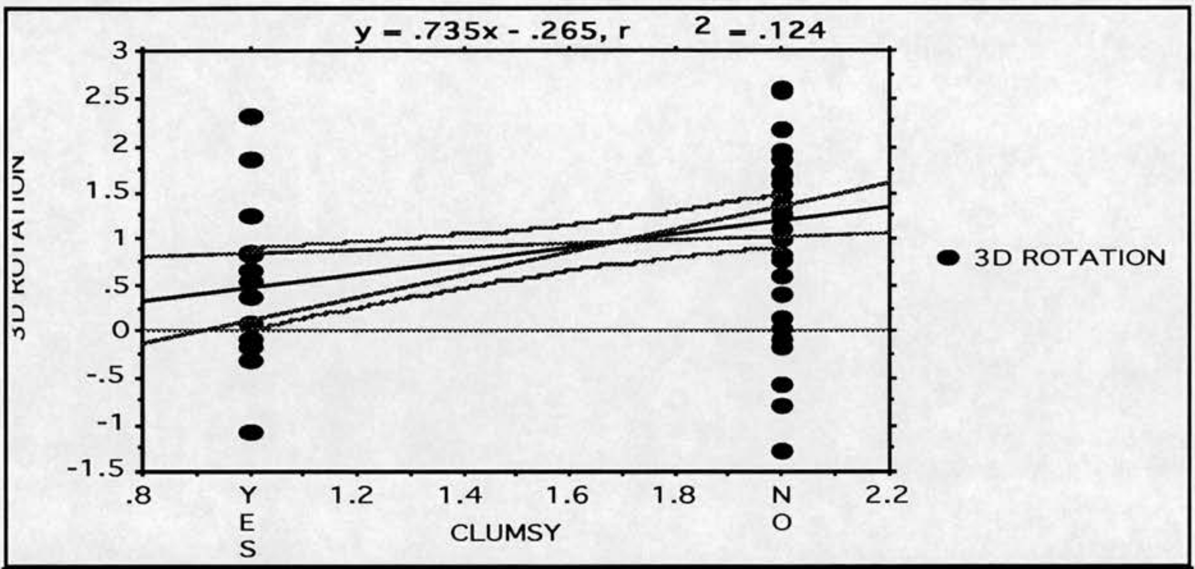


FIGURE SIX: REGRESSION SCATTERGRAM SHOWING 3D ROTATION SCORES FOR THE SELF-IDENTIFIED 'CLUMSY' VERSUS THE REST (95% ACCURACY LINES SHOWN)

This sub-test contributed heavily to the significant difference on the overall cognitive score [**FIGURE SEVEN**]:

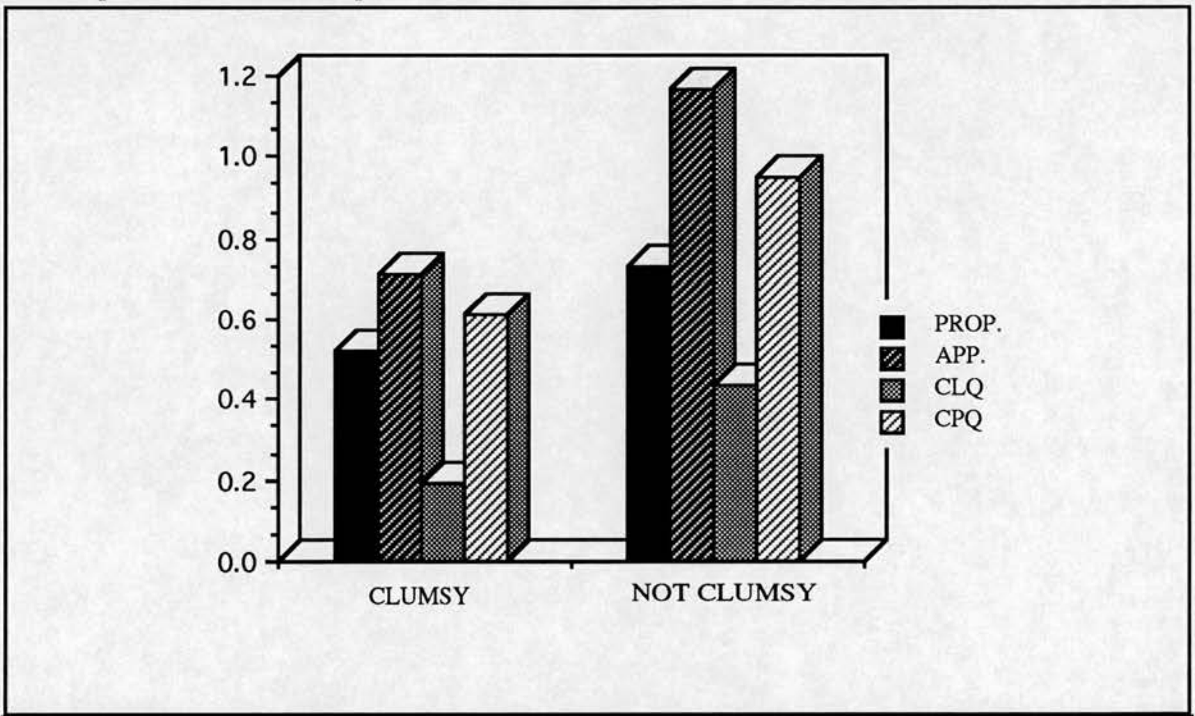


FIGURE SEVEN: BAR CHART OF PROPOSITIONAL, APPOSITIONAL, CLQ, CPQ SCORES FOR THE CLUMSY/NOT CLUMSY GROUPS

Even in the Propositional scoring the means ("**Yes**"=.521/"**No**"=.730) indicated an all-round lower test ability. None of the remaining sub-test comparisons went in the direction of higher scores for the self-reported clumsy.

Eye and Hair Colour

Turning to the other category which proved significant in the earlier Chi-square tests, that of Eye Colour (with its associated pigmentation category of Hair Colour), it may be seen **[FIGURE EIGHT]** that there is a consistent superiority in cognitive scoring by those in the Dark Eyed category over those in the Light Eyed:

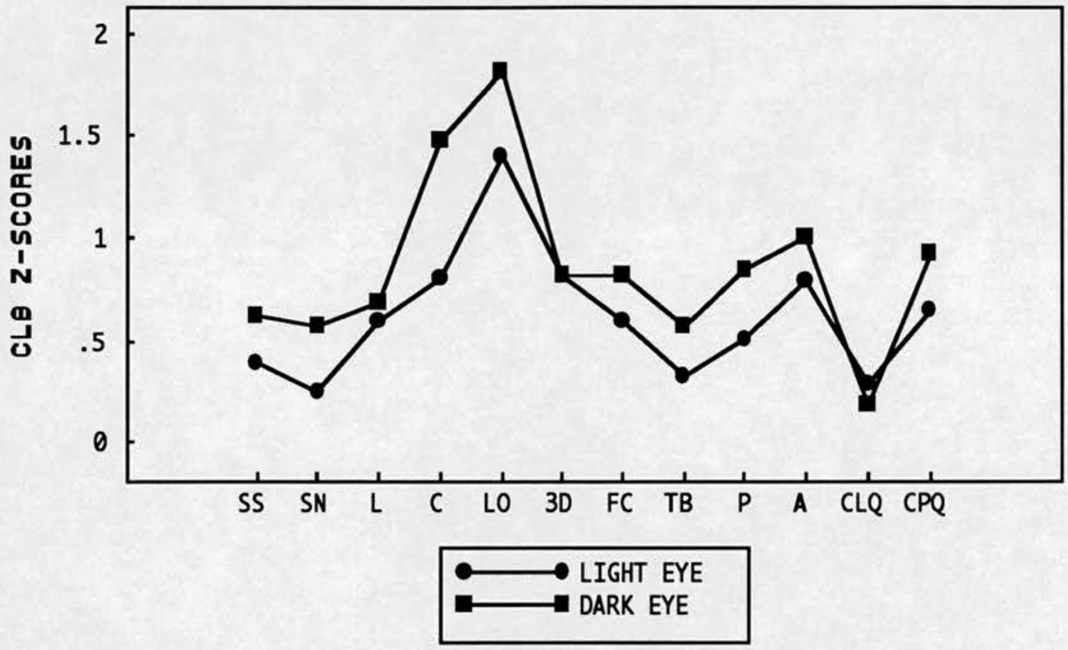


FIGURE EIGHT: COMPARISON OF ALL CLB SUB-TEST SCORES FOR DARK EYED AND LIGHT EYED GROUPS

An Analysis of Variance was carried out to ascertain whether or not these were significant differences overall **[TABLE TWELVE]**:

CPQ-Cognitive scores

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	2.048	2.048	6.327
Within groups	108	34.957	.324	$p = \underline{.0134}$
Total	109	37.005		

TABLE TWELVE: ANOVA ON CPQ SCORES FOR DARK AND LIGHT EYED

The significant value (underlined) shows that overall there were reliable differences between the scores for the two categories. To analyse these in greater detail, t-tests were conducted; the significant sub-tests are shown below **[TABLE THIRTEEN]**:

Serial Numbers				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
108	-1.826	.0353		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	63	.229	.939	.118
DARK	47	.561	.95	.139
Word Production-Categories				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
108	-3.246	.0008		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	63	.799	1.055	.133
DARK	47	1.465	1.078	.157
Localisation				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
108	-2.048	.0215		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	63	1.386	1.114	.14
DARK	47	1.796	.927	.135
Propositional score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
108	-2.34	.0105		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	63	.498	.758	.096
DARK	47	.829	.701	.102
Appositional score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
108	-1.673	.0487		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	63	.776	.72	.091
DARK	47	.996	.63	.092
CPQ-cognitive score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
108	-2.515	.0067		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	63	.636	.606	.076
DARK	47	.912	.515	.075

TABLE THIRTEEN: EYE COLOUR CLB SCORES-T-TESTS

Even though sub-tests from *both* sections of the Eye Colour data showed significant differences, the major effect was in the Propositional area, which indicated that light-eyed individuals were generally less able on verbal-sequential tasks than dark-eyed individuals. There were no sub-tests where the light-eyed outscored the dark-eyed [**FIGURE NINE**].

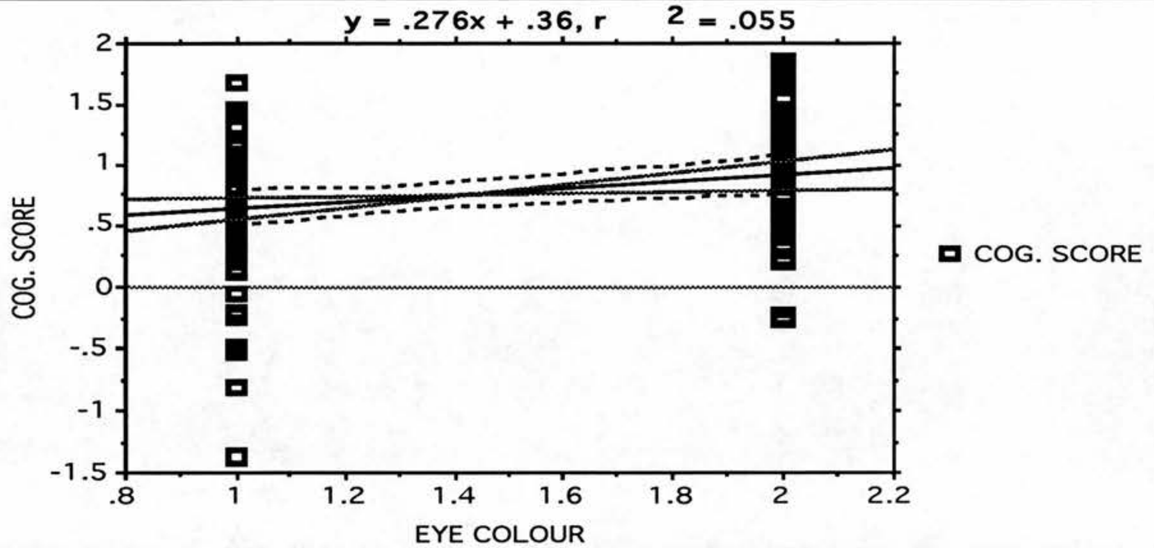


FIGURE NINE: REGRESSION GRAPH OF CPQ COGNITIVE SCORES FOR LIGHT (1) AND DARK (2) EYED (95% CONFIDENCE BANDS SHOWN)

Clearly, the area of strength of the dark eyes was Propositional performance, with a lesser contribution from the visual-spatial scoring.

Eye And Hair Colour-High/Low CPQ Groups Scores;

If the High and Low Groups, as measured by scores on the Cognitive Performance Quotient of the CLB, are examined in some detail in relation to eye colour, some of the trends masked by the central corpus (54) of moderately scoring subjects are thrown into sharper relief [**FIGURE TEN**]:

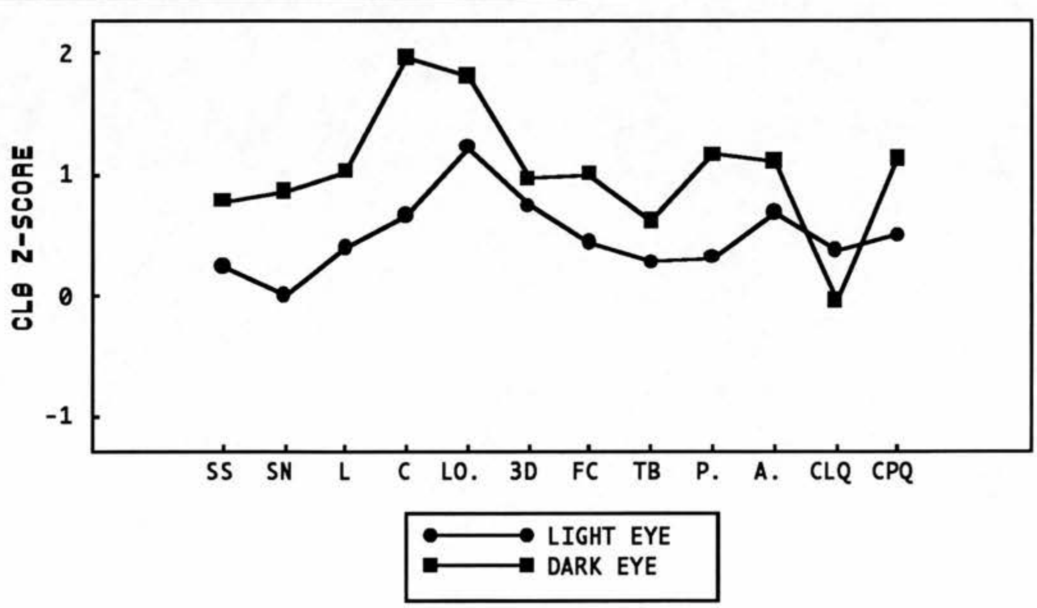


FIGURE TEN : BOTH HIGH AND LOW CPQ EYE COLOUR GROUPS CLB SCORES

An ANOVA (analysis of variance) was carried out on this data, and was found to show a significant difference between eye colours [underlined in **TABLE FOURTEEN**]:

CPQ-Cognitive score Analysis of Variance Table				
Source:	**DF:**	**Sum Squares:**	**Mean Square:**	**F-test:**
Between groups	1	5.472	5.472	10.145
Within groups	54	29.128	.539	p = .0024
Total	55	34.6		

TABLE FOURTEEN: ANOVA ON EYE COLOUR IN THE HIGH/LOW CPQ GROUPS

Looking at both Groups together, and studying only the last four scores of the CLB, the following results are seen:

Propositional scores				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
54	-3.726	.0002		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	32	.295	.859	.152
DARK	24	1.134	.797	.163
Appositional scores				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
54	-1.853	.0347		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	32	.647	.908	.161
DARK	24	1.071	.757	.155
Cognitive Laterality scores-Right Hemisphericity				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
54	1.884	.0324		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	32	.353	.765	.135
DARK	24	-.063	.883	.180
CPQ-cognitive scores				

DF:	Unpaired t Value:	Prob. (1-tail):		
54	-3.185	.0012		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	32	.470	.797	.141
DARK	24	1.101	.641	.131

TABLE FIFTEEN: EYE COLOUR EFFECTS IN HIGH/LOW GROUPS-T-TESTS

The effect of combining High and Low groups when looking at Eye colour is to accentuate the differences between Light and Dark groups. The great superiority of the dark-eyed over the light-eyed performance on these tests is clearly shown by the above, with significant differences between mean scores in every section [underlined in **TABLE FIFTEEN** and illustrated in **FIGURE ELEVEN**].

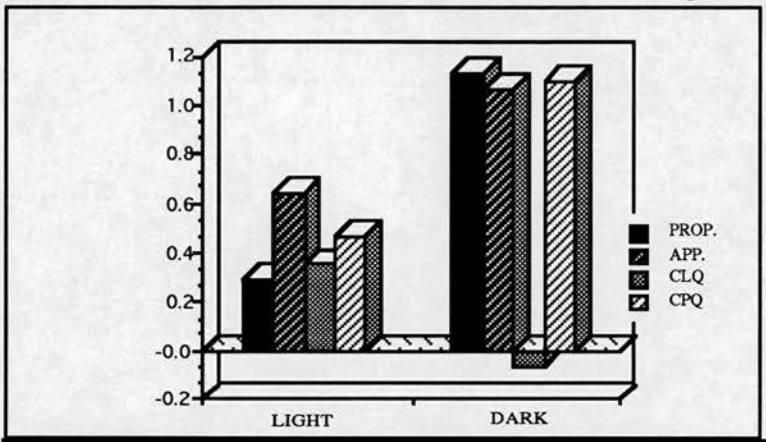


FIGURE ELEVEN: COMPARISON OF LIGHT AND DARK EYE COLOUR SCORES IN THE LAST FOUR CLB Z-SCORES IN THE HIGH /LOW CPQ SCORING GROUPS COMBINED

The CLQ may be picked out as especially interesting: it shows that the light-eyed in the top and bottom CPQ 30 Groups combined are significantly more ($p<.05$) "right hemisphere" in their lateralisation than the dark-eyed. The only note of caution which may be sounded here is that the Standard Deviations for the light eyed are all greater than their score means, something which points to a non-normal distribution; however, as both High and Low Groups are combined, wide differences in scoring should be expected. This applies far less to the dark eyed Groups, because most of them are in the High 30, and are therefore more homogeneous in scoring.

A Simple Regression [**TABLE SIXTEEN**] carried out on Eye Colour in the High/Low Groups produced a significant p-value (underlined), and an explanation of around 15% of the variance:

Count:	R:	R-squared:	Adj. R-squared:	RMS Residual:
56	.398	.158	.143	.734
Analysis of Variance Table				
Source	**DF:**	**Sum Squares:**	**Mean Square:**	**F-test:**

REGRESSION	1	5.472	5.472	10.145
RESIDUAL	54	29.128	.539	p = .0024
TOTAL	55	34.600		

TABLE SIXTEEN: REGRESSION ON EYE COLOUR IN HIGH/LOW CPQ SCORES GROUPS

A regression graph [**FIGURE TWELVE**] shows this again:

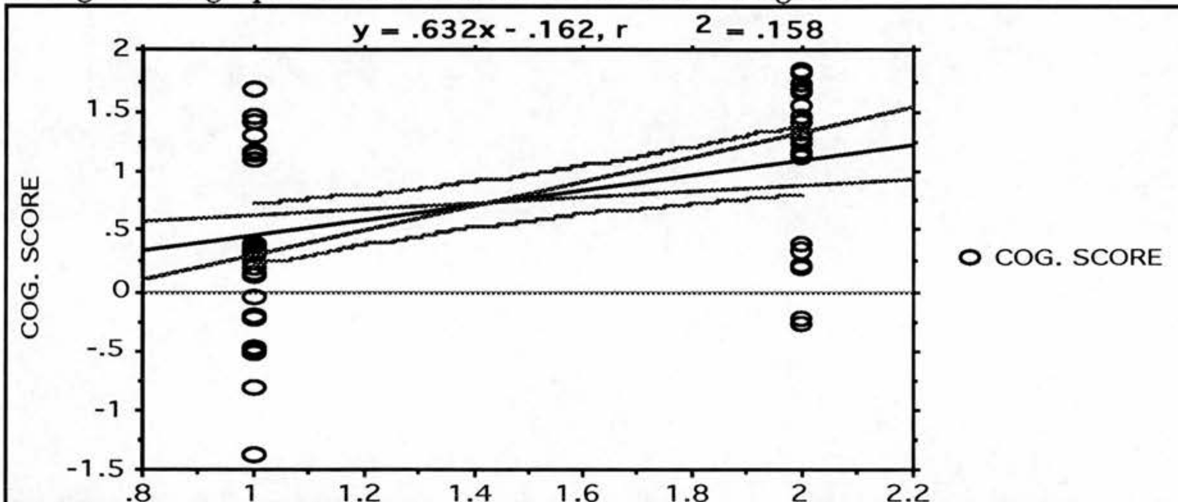


FIGURE TWELVE: REGRESSION ON GRAPH OF EYE COLOUR [LIGHT=1, DARK=2] AND CPQ IN THE HIGH/LOW GROUPS

Even *within* the two sets of 30 there emerge interesting eye colour differences, shown most strongly in the overall Propositional scores [**TABLE SEVENTEEN**]:

Propositional scores				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
24	-1.821	.0406		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	20	-.238	.594	.133
DARK	6	.243	.456	.186

TABLE SEVENTEEN: EYE COLOUR IN LOW CPQ GROUP ONLY

The sub-test contributing most strongly to this significant difference between eye colour scores was Word Production-Categories, as shown by the Regression graph and the bar graph [**FIGURES THIRTEEN AND FOURTEEN**]:

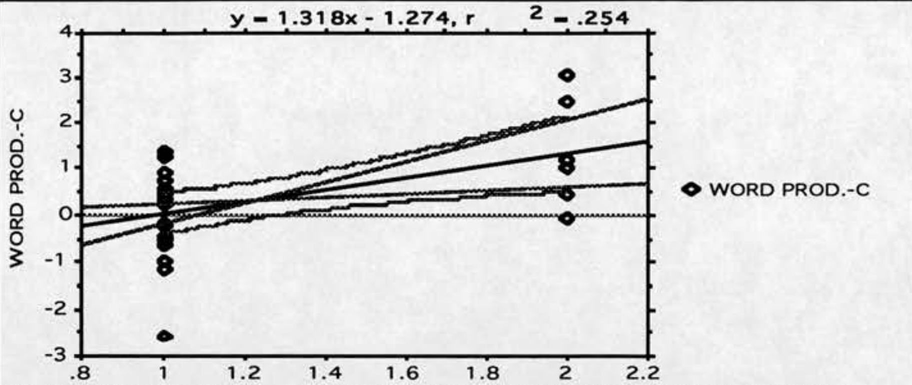


FIGURE THIRTEEN : REGRESSION ON GRAPH OF EYE COLOUR [LIGHT=1, DARK=2] IN THE LOW 30 CPQ SCORES ONLY

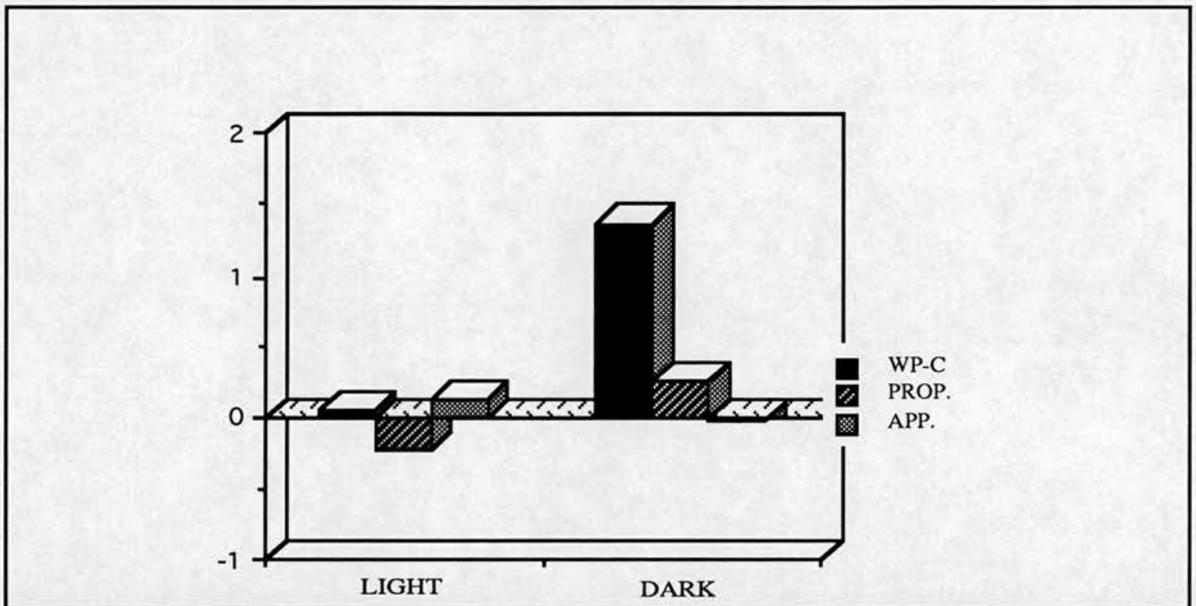


FIGURE FOURTEEN: BAR CHART OF PROPOSITIONAL AND APPOSITIONAL SCORES WITH THE WP-C SUB-TEST AS A COMPARISON IN THE LOW CPQ SCORES GROUP ONLY

It may be seen that even in the Low 30 there are significant differences in lateralisation, the small number of dark-eyed retaining a reasonably strong "left hemisphere" dominance.

HIGH CPQ SCORES GROUP ONLY

If the High CPQ scores Group is studied, it seems that there is an overall difference, which shows itself more in the Propositional tests, as shown in the graph [**FIGURE FIFTEEN**].

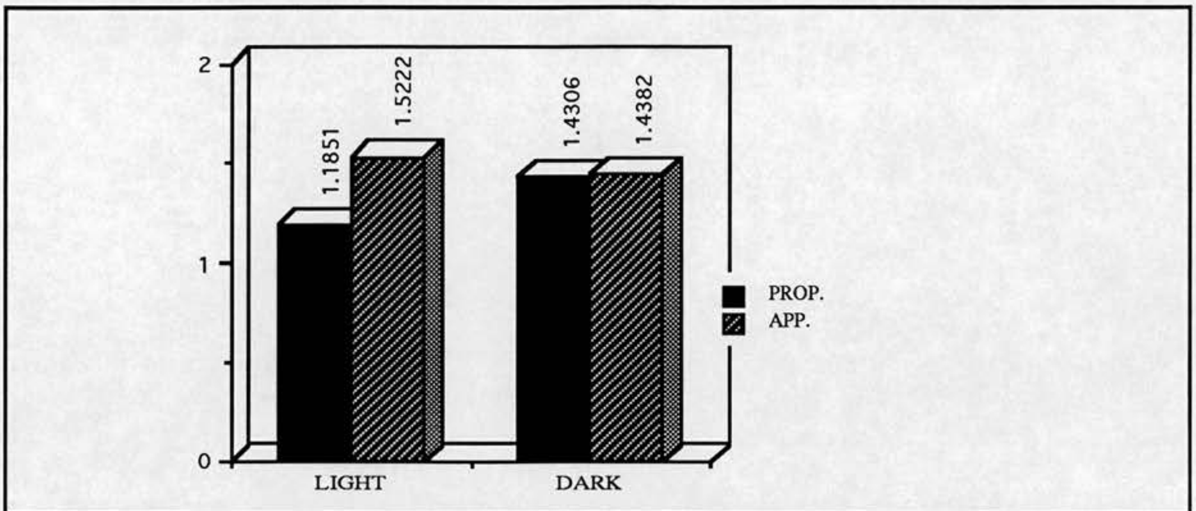


FIGURE FIFTEEN: BAR CHART COMPARISON OF DIFFERENCES BETWEEN PROPOSITIONAL AND APPOSITIONAL TESTS OF THE CLB IN THE HIGH SCORES GROUP ONLY

There are statistically significant differences in both Serial Numbers and Localisation sub-tests [**FIGURE SIXTEEN**]:

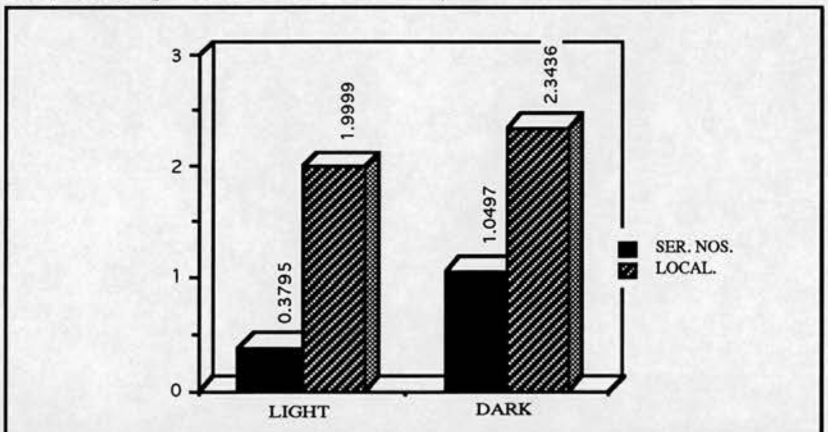


FIGURE SIXTEEN: BAR CHART OF SERIAL NUMBERS AND LOCALISATION SUB-TESTS COMPARISON, HIGH CPQ SCORES GROUP ONLY

It is clear that the two eye colours differ even when the highest scoring individuals are considered [significant values underlined in **TABLE EIGHTEEN**].

Serial Numbers scores				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
28	-2.256	.0161		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	12	.380	.744	.215
DARK	18	1.050	.830	.196
Localisation scores				

DF:	Unpaired t Value:	Prob. (1-tail):		
28	-1.907	.0334		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
LIGHT	12	2.000	.549	.158
DARK	18	2.344	.436	.103

TABLE EIGHTEEN: EYE COLOUR IN HIGH CPQ SCORES GROUP ONLY

HAIR COLOUR-HIGH/LOW GROUPS

Obviously closely associated with eye colour is hair colour; although both may not derive from the same cells in embryological development, there seems to be a positive correlation between amount of eye/hair pigmentation and CNS neuromelanin. In the CLB tests, the light-haired scored less well than the dark-haired, echoing the eye colour results

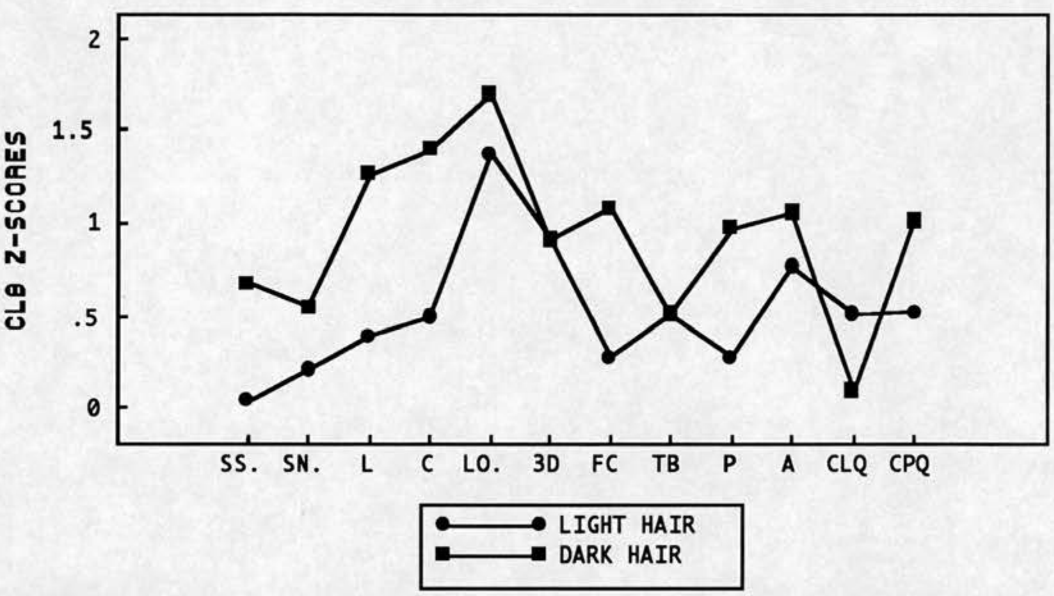


FIGURE SEVENTEEN : COMPARISON OF ALL SUB-TESTS BETWEEN LIGHT AND DARK HAIRED IN THE HIGH/LOW CPQ GROUPS

It may be seen that, while the picture is confused after the 3d Rotation sub-test, there is a clear advantage to the dark haired in the Propositional tests, in a similar manner to the findings for eye colour [**FIGURE SEVENTEEN**]. Accordingly, ANOVAs were carried out on the whole CLB and the Propositional sub-tests only; however, neither proved to be significant, probably due to reduced numbers of subjects. T-tests were nevertheless carried out on individual parts of the CLB scores, with the results shown [significant values <u>underlined</u> in **TABLE NINETEEN**]:

Word Production-Letters				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
30	-1.757	.0445		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	12	.375	1.201	.347
DARK	20	1.248	1.445	.323
Word Production-Categories				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
30	-2.055	.0243		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	12	.484	1.197	.346
DARK	20	1.38	1.193	.267
Form Completion				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
30	-2.208	.0175		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	12	.257	1.277	.369
DARK	20	1.071	.815	.182
Propositional score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
30	-1.891	.0342		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
LIGHT	12	.256	.959	.277
DARK	20	.959	1.049	.234

TABLE NINETEEN: HAIR COLOUR; HIGH/LOW CPQ GROUPS

Because of the low numbers of subjects and the size of the standard deviations, only limited reliance may be placed on these findings.

LATE WINTER BIRTH

The category of Late Winter Birth, in the four months of February, March, April, and May, when used to divide the CLB test scores produces the clear pattern shown below [**FIGURE EIGHTEEN**], where virtually all LWB scores were inferior to those from the Not LWB Group:

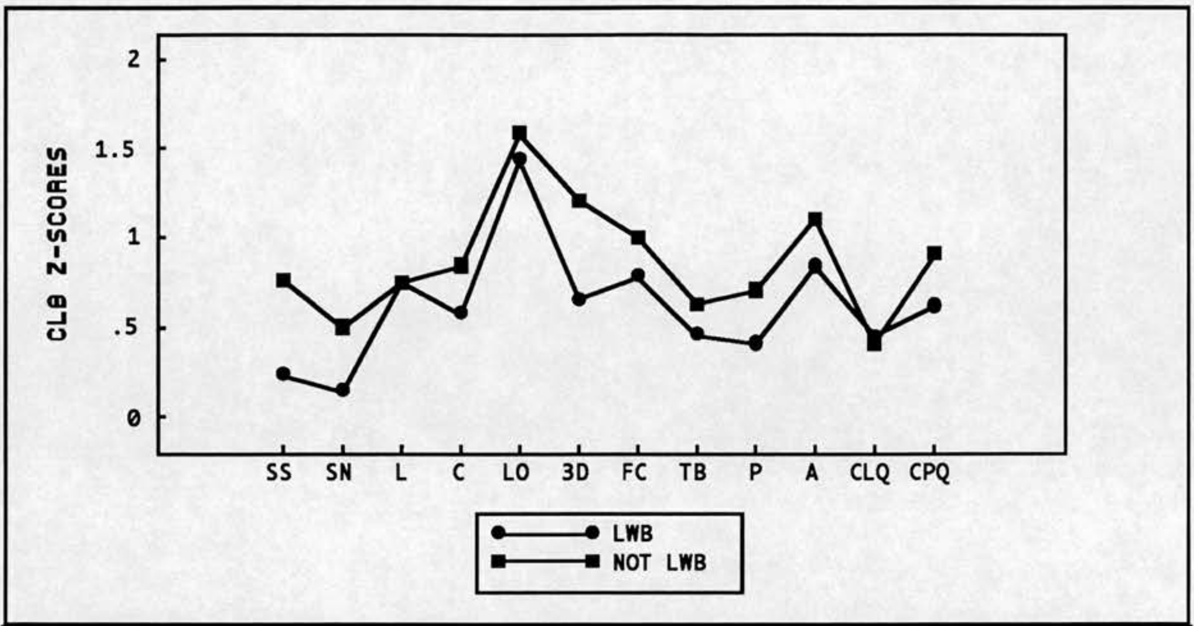


FIGURE EIGHTEEN : LWB (LATE WINTER BIRTH) / NOT LWB GROUPS-ALL CLB SCORES COMPARED

If the final four scores of the CLB are examined for the LWB/NOT LWB category, a strongly suggestive picture emerges of the nature of the differences, as shown below [**FIGURE NINETEEN**]:

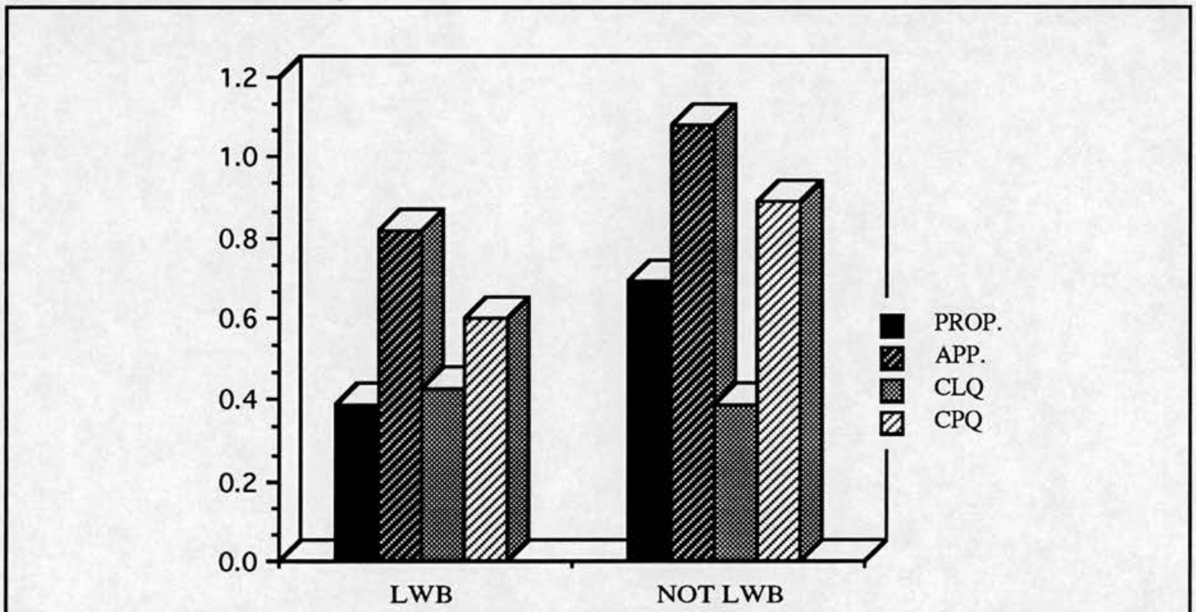


FIGURE NINETEEN: BAR CHART OF LWB (LATE WINTER BIRTH) / NOT LWB GROUPS-PROPOSITIONAL, APPOSITIONAL, CLQ, AND CPQ SCORES

In **Table Twenty** can be seen the significant difference between the CPQ scores of the LWB/NOT LWB groups (underlined value):

CPQ-Cognitive scores				
Analysis of Variance Table				
Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	1.547	1.547	5.438
Within groups	78	22.188	.284	p = .0223
Total	79	23.735		

TABLE TWENTY: ANOVA ON LWB/ NOT LWB- ALL SUBJECTS' CPQ SCORES

Specific sub-test differences are detailed below [**TABLE TWENTY-ONE**]:

Serial Sounds sub-test				
DF:	Unpaired t Value:	Prob. (1-tail):		
78	-2.036	.0225		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
YES	30	.224	1.176	.215
NO	50	.738	1.040	.147
Serial Numbers sub-test				
DF:	Unpaired t Value:	Prob. (1-tail):		
78	-1.668	.0497		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
YES	30	.134	.877	.160
NO	50	.488	.942	.133
Spatial Rotation-orientation sub-test				
DF:	Unpaired t Value:	Prob. (1-tail):		
78	-2.542	.0065		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
YES	30	.638	1.055	.193
NO	50	1.185	.850	.120
Propositional score				
DF:	Unpaired t Value:	Prob. (1-tail):		
78	-1.836	.0351		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
YES	30	.386	.771	.141
NO	50	.694	.699	.099

Appositional score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
78	-1.837	.035		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	30	.817	.750	.137
NO	50	1.084	.544	.077
CPQ-cognitive score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
78	-2.332	.0111		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	30	.602	.599	.109
NO	50	.889	.490	.069

TABLE TWENTY-ONE : LWB/NOT LWB CATEGORY SUB-TESTS -T-TESTS (significant values underlined)

Once again, it is clear that those born in the four months February, March, April, May (and thus thought to stand the greater risk of developing schizophrenia), do not score as highly as those born at other times. If what has been postulated earlier concerning deleterious influences causing schizophrenia is accepted, those same deleterious influences, when not producing in some individuals a clearly defined pathology such as schizophrenia, may produce relatively lowered cognitive abilities in many, even the most highly able University students, as perhaps has been shown by the CLB scores.
An interesting association is that of LWB with Allergies (df=1, Phi=.253, Chi-square=4.649, p=.0311), where 65.62% of those born in the late winter have allergies as well; only 24.4% of those with allergies were late winter born. It may be expected that those born at the time of the year when pollen and house mites and dust are at their worst will be more likely to develop allergies.

MAIN SIGNIFICANT CATEGORIES COMPARED

An analysis of variance on all three characteristics, using only the overall CPQ measures, produced an interesting indication of how they interact: Clumsiness did not covary with Eye colour or Late Winter Birth scores. The Incidence Table [**TABLE TWENTY-TWO**] clearly shows that the Dark eyed scored best-birth in late winter made little difference to the dark-eyed, but seemed to severely affect the light-eyed, who scored less well than the dark-eyed regardless of period of birth. The lowest scores were nearly all by those who shared the three disadvantageous somatic factors. In the light eyes, those who did not have clumsiness or who were not born in February to May scored highest; the situation in the dark eyes was more complex, but seemed to indicate that most of them, as well, benefited from being without the disadvantageous factors. Overall, the ANOVA produced one main effect for eye colour (F-test=4.662, df=1/45, p=.0362) in the CPQ scores.

Source:	Degrees of Freedom	Sum of Squares:	Mean Square:	F-test:	P value:
LATE WINTER BIRTH (A)	1	.036	.036	.11	.7414
EYE COLOUR (B)	1	1.53	1.53	4.662	.0362
AB	1	.448	.448	1.364	.249
CLUMSY (C)	1	.097	.097	.295	.5899
AC	1	.116	.116	.353	.5554
BC	1	.134	.134	.41	.5254
ABC	1	.153	.153	.467	.4981
Error	45	14.764	.328		

TABLE TWENTY-TWO: THREE FACTOR ANOVA ON CPQ SCORES FOR LWB, EYE COLOUR AND CLUMSINESS

The Incidence Table shows that, in the Light eye group with the taking away of each deleterious factor the CPQ scores rise accordingly: .336 to .619 to .690 to .934. No such linear progression is observable in the Dark eye group:

	EYE COLOUR:	LIGHT		DARK		Totals:
	CLUMSY:	YES	NO	YES	NO	
LATE WIN.:	YES	8 .336	7 .619	2 1.372	3 1.066	20 .648
	NO	6 .69	14 .934	1 .901	12 1.164	33 .972
Totals:		14 .487	21 .829	3 1.215	15 1.144	53 .85

TABLE TWENTY-THREE: INCIDENCE TABLE FOR CPQ-COGNITIVE SCORES-EYE COLOUR, L.W.B. AND CLUMSINESS

Early Walking/Speech, Sex, Hair/Eye Colour; Child Illness, Clumsiness, Allergies and Familial Allergies, Asthma, Myopia and Familial Myopia

There were several further characteristics of the health or constitution of subjects which significantly associated together:

N	df	Phi	Chi Square	prob.	variables	
64	1	.371	6.322	.0119	Early walking	vs Child illness
64	1	.358	5.486	.0192	Early walking	vs Early speech
65	1	.304	4.638	.0313	Child illness	vs Allergies
65	1	.309	4.266	.0389	Child illness	vs Asthma

66	1	.451	10.615	.0011	Asthma	vs Familial asthma
65	1	.327	5.500	.019	Eye colour	vs Familial allergy
66	1	.388	8.274	.004	Clumsiness	vs Myopia
66	1	.455	11.699	.0006	Myopia	vs Familial myopia
79	1	.465	15.216	.0001	Eye colour	vs Hair colour
66	1	.281	4.121	.0424	Late Winter Birth	vs Allergies
65	1	.336	5.993	.0144	Familial allergy	vs Allergies

TABLE TWENTY-FOUR: CHI SQUARE TESTS FOR ASSOCIATIONS BETWEEN SOMATIC CHARACTERISTICS

62.5% of those who walked early had extensive illness as a child; of those who did not walk early, only 16.07% had child illness. 35.71% of those with child illness walked early, while those without such illness who walked early amounted to a mere 6%. It is strange that having frequent illnesses as a child should spur one on to walk early; it is an anomalous finding, if that, indeed, is the true cause and effect interpretation; it may be that the association is an artefact of the sample. Only 13.6% of the variance in each variable was explained by the other one, indicating the existence of much more influential unknown factors. Early speech was significantly associated with early walking: 40% of those who were early walkers were also early speakers, while only 7.41% of normal or slow walkers were early speakers; 50% of early speakers were able to walk early, with but 10.71% of normal or slow speakers able to do so. It seems that precocity in both is common (with, as will be described later, early reading and writing), thus supporting the case for there being individuals in whom there is across the board precocious motor co-ordination.

50% of the sample had allergies, compared with Benbow's quoted norm of 20% to 25% for the normal population. 53% of Benbow's precocious mathematicians (1986) had allergies. This sample clearly resembles hers more than the normal population. 80% of those who admitted to extensive child illness had allergies, as well; 44% of those without child illness had allergies; only 9.68% of those without allergies had child illness, too, while 35.29% of those with allergies had child illness. It appears that a moderately large proportion of child illness may be allergic in nature, or associated with allergies. There would seem to be some support for the heritability of allergies; 81.82% of those who said that one or more of their close relatives had allergies had allergies themselves, while 72.73% of those whose near relatives had no allergies were without them, too. Allergies were found by Benbow to be a marker for precocious mathematical ability, so perhaps they are a marker for precocity in general.

33.33% of those reporting child illness had asthma; 8% of those without child illness suffered from asthma; 55.6% of those with asthma had extensive childhood illness (not a surprising finding), and only 17.86% of those without asthma had childhood illness. It seems likely that there are many other causes of childhood illness, but asthma is a major one. Allergies produce symptoms similar to asthma in some children, so there may be a merging of these two categories shown here, caused by a confusion in diagnosis, or an error in the identification of the illness by the subject.

38.89% of those who said that there was asthma in the family had asthma themselves, as well, while only 4.17% of those who said that there was no asthma in the family suffered from asthma; 77.78% of asthmatics had familial asthma, too, but 61.11% of non-asthmatics had cases of asthma in the family. 30% of the variance in one variable was explained by the other one. A possible hereditary predisposition to asthma is highlighted here.

There was a significant association of familial allergies and eye colour **[TABLE TWENTY-FOUR]**: 81.4% of those with familial allergies had light eyes, while 18.6% had dark eyes; however, 50% of those without familial allergies were light eyed, somewhat reducing the initial spectacular difference. Nevertheless, 50%, again, of the dark-eyed had allergies in the family, but 76.09% of the light-eyed had them. There seems to be an association between having light iris pigmentation and familial allergy, although none was found with personal allergy. This may point to a hereditary component for the eye colour which is linked with allergy; light eyed individuals may have the potential or predisposition to be allergic but this may not become manifest in them.

50% of this sample were myopic, exactly the same as was reported of Benbow's precocious mathematicians (1986). 46.88% of the myopic also report themselves to be clumsy, while only 11.76% of those without myopia have claimed clumsiness; 78.95% of the clumsy say they are myopic, with 36.17% of the non-clumsy having short sight. It may be said that myopics are clumsy, especially before spectacles are prescribed, because they cannot see what they are falling over; nevertheless, 21.05% were of good sight and clumsy-it is possible that the two conditions "arrive as a pair", so to speak, more often than they do separately, deriving from some general lowering of somatic motor ability.

65.96% of those whose families had myopics in them were themselves myopic, while only 15.79% of the non-familial myopic group had myopia; 91.18% of the myopics said that there was myopia in the family, with 50% of the non-myopics saying the same. 20% of the variance in one variable was explained by the other one. The hereditary nature of myopia is clearly illustrated here, as was the case with allergies and asthma, although substantial room is left for those who wish to argue an epigenetic or environmental influence.

88.89% of those who were light-haired were light-eyed, as well, while 44.19% of the dark-haired were light-eyed; 62.75% of the light-eyed were light-haired, with 14.29% of the dark-eyed having light hair. 25% of the variance in one variable was explained by the other one. Few students tint or bleach their hair, but the finger of suspicion may well point at those who were light haired with dark eyes! Interestingly, the correlation between hair colour and eye colour would argue against what are thought to be the biochemically different origins of the pigmentation of eye and hair, perhaps supporting the existence of a common precursor: enzymatic, anatomical, or genetic.

Lastly, there was found to be a significant association **[TABLE TWENTY-FOUR]** between Late Winter birth and Allergies; only 24.24% of the non-allergic were LWB;

68% of the LWB were allergic. Perhaps the speculated causes of the disorders suffered more by the Late Winter born produce, as well, the predisposition to be allergic.

OTHER SOMATIC CATEGORIES-CLB SCORES

If the various significantly associated categories noted in **Table Twenty-four** are used to divide the scores on the CLB test, a clearer picture may emerge of the varying degrees of apparently associated disadvantage sketched-in by the Chi Square results. Looking at Child illness first, it may be seen that only two sub-tests, Serial sounds and Localisation, gave significant differences [underlined in **TABLE TWENTY-FIVE**]:

Serial sounds score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
52	-2.259	.014		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	12	-.023	.716	.207
NO	42	.754	1.125	.174
Localisation score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
52	-1.864	.034		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	12	.296	.858	.248
NO	42	.690	.575	.089

TABLE TWENTY-FIVE: CLB SCORES FOR CHILD ILLNESS /NO CHILD ILLNESS GROUPS -T-TESTS

It would be difficult to draw conclusions from the above, except that the other sub-tests showed a similar trend toward the better scores coming from those who did not admit Child illness. Child illness did divide the sample significantly ($p<.02$) on Hand score: those with persistent childhood illness (16) scored a mean of 13.625 (SD=4.843), while those who did not so suffer (59) scored a mean of 15.797 (SD=2.709) [df=73, t-value unpaired=-2.361, p=.0105], indicating that those who had been severely and persistently ill as a child were more likely to be left-handed, thus providing more support for the Geschwind and Galaburda and "pathological left-handedness" hypotheses.

CLB t-test values were as follows:

Word production-letters score		
DF:	**Unpaired t Value:**	**Prob. (1-tail):**
55	3.168	.0012

Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	28	1.227	.758	.143
NO	29	.308	1.343	.249
Word production-categories				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
55	1.984	.0261		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	28	1.173	.840	.159
NO	29	.624	1.209	.225
Propositional scores				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
55	2.387	.0102		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	28	.890	.709	.134
NO	29	.362	.941	.175
CLQ-Right hemisphericity				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
55	-1.73	.0446		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	28	.172	.811	.153
NO	29	.595	1.019	.189
CPQ-Cognitive score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
55	1.903	.0312		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	28	.976	.560	.106
NO	29	.66	.688	.128

TABLE TWENTY-SIX CLB SCORES FOR THE ALLERGY /NO ALLERGY GROUPS-T-TESTS

This category produced a reasonably convincing division of scores between those who claimed to be allergic in one way or another and those who said they were not [**TABLE TWENTY-SIX**]. Verbal fluency contributed most of the variance in the Propositional scoring; particularly interesting was the finding that those who said they were <u>not</u> allergic were significantly more right hemispheric, according to the CLB rationale. The

Cognitive score showed that having allergies seemed to be linked to better performance overall, as was predicted.
Myopia was the next characteristic to be analysed through the CLB scores:

Hand score				
DF:	Unpaired t Value:	Prob. (1-tail):		
47	1.723	.0457		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
YES	27	15.519	2.751	.529
NO	22	13.773	4.298	.916
Serial sounds score				
DF:	Unpaired t Value:	Prob. (1-tail):		
55	-2.133	.0187		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
YES	31	.197	1.128	.203
NO	26	.826	1.087	.213

TABLE TWENTY-SEVEN: CLB SUB-TEST AND HAND SCORE SIGNIFICANT DIFFERENCES FOR THE MYOPIA /NO MYOPIA GROUPS-T-TESTS

The category Myopia produced just one sub-test difference of any note [**TABLE TWENTY-SEVEN**], but in addition to that of the Serial sounds sub-test, showed a significant difference in Hand score, the myopic being significantly more right-handed than the non-myopic. There were no hypotheses linking these two characteristics.
Familial asthma was looked at next:

Word production-Categories score				
DF:	Unpaired t Value:	Prob. (1-tail):		
53	-1.87	.0335		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
YES	15	.498	1.173	.303
NO	40	1.092	1.001	.158
Touching blocks score				
DF:	Unpaired t Value:	Prob. (1-tail):		
53	-2.621	.0057		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:

YES	15	.095	1.107	.286
NO	40	.688	.565	.089

TABLE TWENTY-EIGHT: CLB SCORES FOR FAMILIAL ASTHMA/NO FAMILIAL ASTHMA GROUPS-T-TESTS

Familial asthma yielded just two significant results for sub-tests: Word production-categories and Touching blocks [**TABLE TWENTY-EIGHT**]. In general, the trend for the other sub-tests was the same as in these, that those who said there was asthma in their families scored less well than those who said none of their relatives had asthma, again, as was predicted.
The Asthma variable gave an almost significant t-test probability value (df=47, t-value=-1.653, p=.0525) on the Hand scoring, with the 6 who said they had asthma scoring a mean of 12.500 as opposed to those (43) without asthma who scored a mean of 15.047; this indicated that the asthmatic may have more of a tendency toward left-handedness than the right-handed, thus providing some weak support for the Geschwind and Galaburda theory hypotheses.

PSYCHOLOGICAL VARIABLES

Math Ability

There was one significant psychological factor found to distinguish between High and Low CPQ Groups according to the Chi-Square tests, and that was claiming mathematical talent.

N	df	Phi	Chi Square	prob.	variable	
29	1	.647	9.469	.0021	H/L CPQ Group	vs Math ability
51	1	.415	7.104	.0077	Math ability	vs Graphic/Painterly
44	1	.571	12.108	.0005	Colour/BW	vs Graphic/Painterly
66	1	.501	14.506	.0001	Culture	vs Math ability
47	1	.554	12.192	.0005	Culture	vs Need to draw
65	1	.364	7.159	.0075	Culture	vs Monotalent
46	1	.480	8.661	.0033	Monotalent	vs Need to draw
46	1	.372	4.928	.0264	Need to draw	vs Antisocial
47	1	.333	3.944	.0470	Need to draw	vs Math ability
66	1	.334	5.967	.0146	Musical mother	vs Musical ability
56	1	.340	4.780	.0288	Cognitive style	vs Artistic mother
54	1	.322	4.295	.0382	Cognitive style	vs Mathematical father
42	1	.510	8.887	.0029	Colour/BW	vs Imaginative drawing
56	1	.313	3.872	.0491	Artistic mother	vs Realistic/Abstract
56	1	.320	4.482	.0343	Art ability	vs Reality loss
67	1	.344	6.290	.0121	Artistic mother	vs Math ability
56	1	.404	7.577	.0059	Daydreamer	vs Reality loss
67	1	.491	14.120	.0002	Math ability	vs Monotalent

37	1	.416	4.787	.0287	Graphic/Painterly	vs Early perspective
76	1	.279	4.612	.0318	Culture	vs Artistic Mother

TABLE TWENTY-NINE: CHI SQUARE TESTS FOR ASSOCIATIONS BETWEEN PSYCHOLOGICAL CHARACTERISTICS

No less than 94.12% of those in the High 30 claimed mathematical ability, while 33.3% of the Low 30 claimed similarly. Of those who admitted to having not a shred of math talent, only 11.11% were to be found in the High 30, while of those who claimed mathematical ability, 80% were to find their way into the High 30. It follows that 66.67% of the Low 30 declared they had no math ability. Nearly 47% of the variance in one variable could be explained by the other. As there were two cells in the Chi Square table with less than 5 expected subjects, a Fisher's Exact test was carried out, which found that a predicted (1-tail) association produced a probability of .00086 and the probability of the observed table was .00084, thus supporting the Chi Square results [**TABLE TWENTY-NINE**].

The variable Mathematical ability was explored further, in relationship with other variables, only one other being found which yielded a significant association: 75.76% of those with math ability preferred graphic art, while 33.33% of non-mathematically able individuals preferred such art; 80.65% of the group which preferred graphic art had math ability, with 40% of those who preferred painterly approaches to art having math ability. 13% of the variance in one variable was explained by the other. It seems that there is an association between being mathematically able and liking the clearer, more linear graphic art of drawing, etching, or prints, while the non-mathematical prefer the looser, less orderly painting with oils or water-colours.

Looking more closely at the links within the area of aesthetic and production styles, graphic versus painterly preferences and colour vs black and white preferences was examined. As expected, there was a tight and significant association between graphic/painting and colour/black-and-white preferences [**TABLE TWENTY-NINE**]: 90.48% of those who preferred black-and-white work also preferred graphic art, while only 34.78% of the group who liked coloured art best liked graphic work as well; 88.24% of the painterly individuals liked coloured art works best, with just 29.63% of the graphics devotees feeling similarly about coloured art; nearly 31% of the variance in one variable was explained by the other. Another variable associated with colour/black and white preference is that of imaginative drawing: 83.33% of those who prefer colour art work say they are able to draw from their imagination, while of those who prefer black and white art only 33.33% have this ability; 75% of those without imaginative powers in art prefer black and white drawings or monochrome art generally.

Culture was found to be significantly associated with mathematical ability: while 40.48% of those with math ability were Arts students, of those who admitted no math ability at all, 91.67% were Arts students; 92.59% of those in the Science disciplines said they had math ability, while 43.59% of the Arts students claimed math ability, too. Culture and Math ability explained 25% of the variance of each other. Another association with Culture was found with Need to draw (NTD), a characteristic thought to be essential for success in visual art: only 12.5% of those Science students who had claimed artistic ability said they had any need to draw, while 70.97% of the Arts students who had claimed similar skills also claimed they needed to draw; 91.67% of the NTD group were Arts students, with 60.87% of the non-NTD group being Science students. Culture and having an artistic mother were associated, 88.24% of those with such a mother were in the Arts category, while those without were almost evenly divided; 31.25% of the Arts individuals as opposed to only 7.14% of the Science people had an artistic mother.

83.3% of those who admitted to having but one talent (i.e., 'monotalented') were Arts students (16.7% Sciences), with 46.36% of the multi-talented being Arts students, too; 51.28% of the Arts students said they were monotalented, while 15.38% of the Science students felt that this was the case. Clearly, most of the multi-talented were to be found in the Sciences (84.62%), a meaningful finding in relation to the fact that both Appositional and Propositional scores were high or balanced in the mathematically able (if one identifies the functions required by the Arts or the Sciences with differing hemispheres).

86.67% of the monotalented have a need to draw (not unexpectedly, as the greater number of both categories are Arts), with 35.48% of the multi-talented having a similar need to draw; 54.17% of the NTD are talented in but one area, with just 13.33% of the non-NTD being monotalented. 17% of the variance in one variable is explained by the other. 76.47% of those who said they had been or still were reluctant to have much to do with other people were also filled with a need to draw, while 37.93% of those who had never felt this dislike of people also had NTD; 54.17% of those with NTD also disliked other people, but for those with no need to draw, only 18.18% preferred their own company. While 45.83% of those with a need to draw had math ability as well, they were outnumbered by those in the no-NTD group (78.26%); 37.93% of those with math ability also had a need to draw, with 72.22% of the non-mathematical having NTD.

86.36% of those subjects with musical ability have musical mothers, while only 12.5% of those who did not have such mothers are also musically able; 45.24% of those with musical mothers have musical ability, although 54.76% of the non-musical have a musically talented mother. The Hand scores of those (45) with musical ability (15.822) were significantly higher and therefore more right-handed ($p<.05$) than those (31) of the subjects without musical ability (14.452) [df=74, t-value unpaired, SD Yes=2.839, No=3.854].

All of those subjects with artistic mothers were Appositional in cognitive style; however, so were 60% of those without such mothers; 28.9% of those who were Appositional had artistic mothers, but none of the Propositional-style subjects had mothers with artistic ability. It seems that an Appositional cognitive style is encouraged by having an artistic mother, either by environmental training or by some inherited predisposition.

85.71% of those with a mathematical father were Appositional in cognitive style, while 54.55% of the subjects who did not have such a father were Appositional in style, as well; 50% of Appositional style individuals had mathematical fathers, with just 16.67% of the Propositional cognitive style people having fathers similarly talented. From the last two findings it appears that perhaps the ideal way to produce in an individual with Appositional thinking is for them to have an artistic mother and a mathematical father!

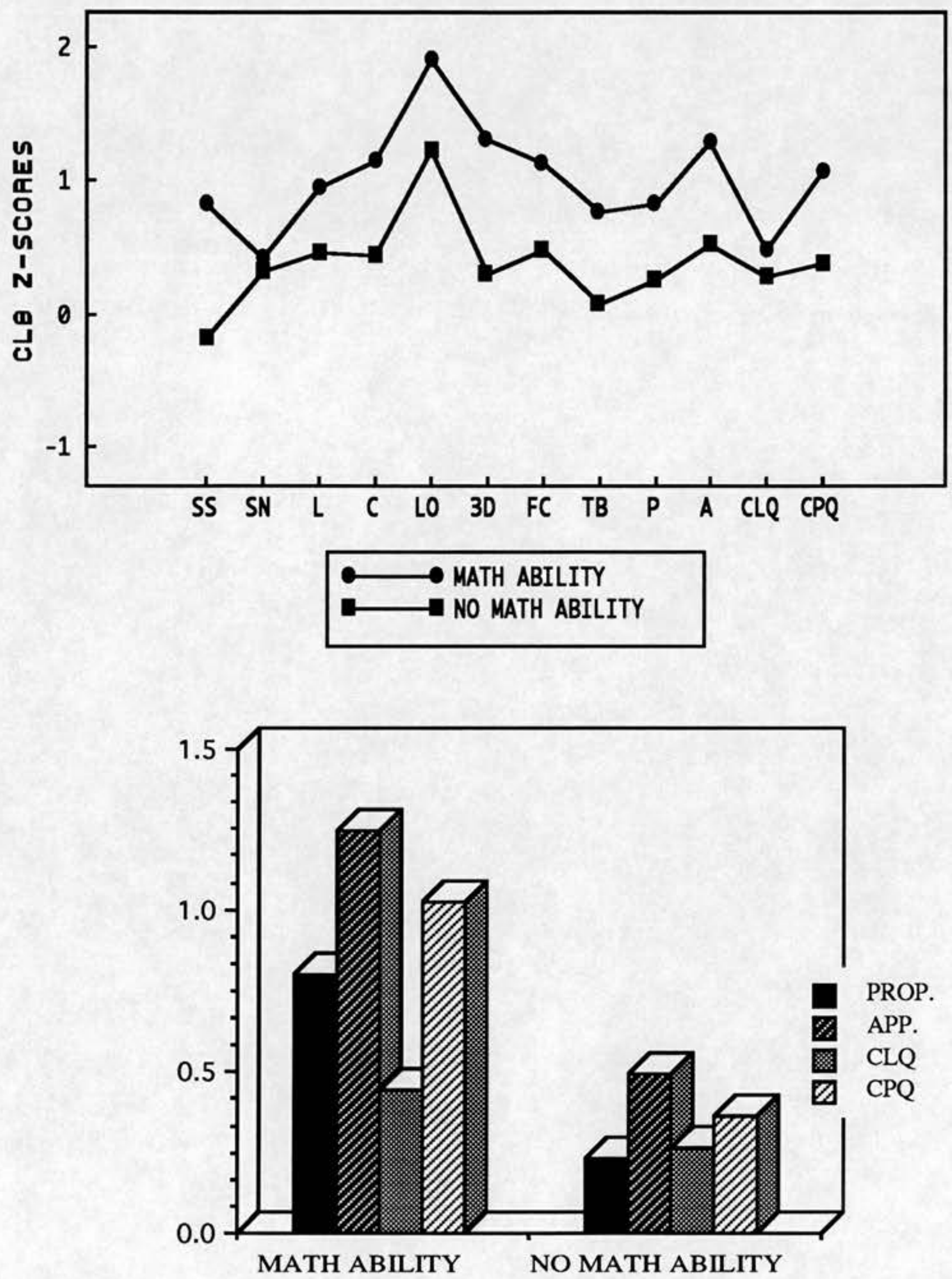


FIGURE TWENTY : COMPARISON OF ALL CLB SCORES FOR MATH/NO MATH CATEGORY. WITH A BAR CHART COMPARISON BETWEEN PROPOSITIONAL, APPOSITIONAL, CLQ, AND CPQ SCORES FOR THE MATH ABILITY/NO MATH ABILITY GROUPS

Over the whole range of scores of the CLB the subjects who stated they believed they had mathematical ability were substantially superior to those who admitted they had no such ability [**FIGURE TWENTY**]. There seems to be a basis in reality (as revealed by the CLB) for the sense conveyed by most of those who say they are not mathematically talented that they are somehow less able cognitively than those with mathematical talents. Interestingly, there seems little difference between the two groups on the sub-test which actually deals with memory for numbers (Serial Numbers [SN]). A measure not on **Figure Twenty** is that of Handedness score, which showed a significant difference ($p<.05$) between those with mathematical ability (49, mean=14.776, SD=3.460) and those who declared themselves without that ability (29, mean=16.241, SD=2.874) [df=76, t-value unpaired=-1.921, p=.0292]. Those without that ability in this sample are therefore, it seems, more right-handed than those with mathematical ability.

An ANOVA of the CPQ scores of the two groups [**TABLE THIRTY**] shows that the overall scoring difference between them was reliably significant (p=.0001).

Analysis of Variance Table				
Source:	**DF:**	**Sum Squares:**	**Mean Square:**	**F-test:**
Between groups	1	5.389	5.389	16.704
Within groups	55	17.744	.323	p = .0001
Total	56	23.133		

TABLE THIRTY : ANOVA ON CPQ SCORE FOR MATH/NO MATH CATEGORY

When the individual CLB test scores are analysed, the nature of the differences illustrated above become clearer [**TABLE THIRTY-ONE**]:

Serial Sounds score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
55	3.324	.0008		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	39	.799	.971	.155
NO	18	-.199	1.217	.287
Word Production-Categories				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
55	2.382	.0103		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	39	1.115	1.040	.167
NO	18	.416	1.005	.237
Localisation				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		

55	2.212	.0155		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	39	1.878	.960	.154
NO	18	1.186	1.356	.320
3d Spatial Rotation				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
55	4.095	.0001		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	39	1.271	.812	.130
NO	18	.273	.945	.223
Form Completion				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
55	2.599	.006		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	39	1.096	.894	.143
NO	18	.448	.830	.196
Touching Blocks				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
55	3.354	.0007		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	39	.743	.570	.091
NO	18	.061	.958	.226
Propositional				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
55	2.389	.0102		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	39	.801	.825	.132
NO	18	.233	.856	.202
Appositional				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
55	4.222	.0001		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	39	1.247	.568	.091
NO	18	.492	.743	.175

CPQ-Cognitive score				
DF:	Unpaired t Value:	Prob. (1-tail):		
55	4.087	.0001		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
YES	39	1.024	.481	.077
NO	18	.362	.726	.171

TABLE THIRTY-ONE: CLB SCORES FOR MATHEMATICAL ABILITY-T-TESTS

Only Serial Numbers, Word Production-Letters and CLQ of the whole range of CLB values proved to be non-significant in the t-test pairwise comparisons, although some of the SDs were disturbingly high, especially for the non-mathematical group.

The margin of difference between the two groups was not small. It seems possible that the CLB could be used to identify those individuals likely to do well on mathematically oriented courses in higher education; on the other hand, the effect of undergoing varying periods of such education may have moulded their still-maturing brains to the effect of producing higher scores on this test! This latter would be true only if degree-level mathematics requires whole brain activity: practising a mathematics which predominantly exercised the right hemisphere could produce the high Appositional scores shown here, but not the almost equally high Propositional scores. Mathematically able students score well across most of the sub-tests. CAT scans have recently shown that mathematical work **is** a whole brain activity (see Literature Review), thus not supporting such lateralisation hypotheses.

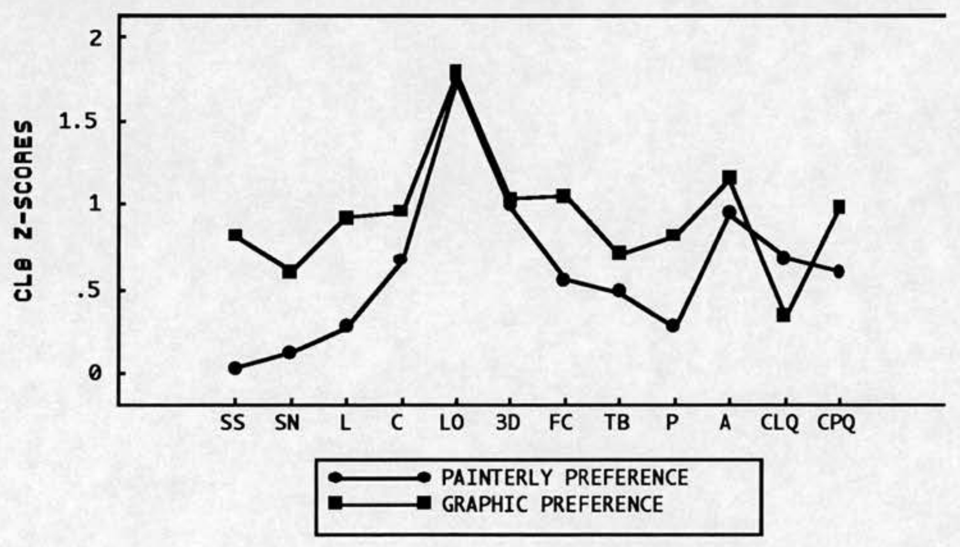


FIGURE TWENTY-ONE : COMPARISON OF CLB SCORES FOR PAINTERLY/GRAPHIC PREFERENCE GROUPS

While this set of comparisons [**FIGURE TWENTY-ONE**] does not provide as clear-cut a picture as the preceding one, nevertheless it shows a reasonably consistent advantage throughout the CLB scores for those who claim to prefer graphic rather than painterly art work. As these may well be the same individuals who, to a great extent, claim mathematical ability, the similar pattern is probably explained.

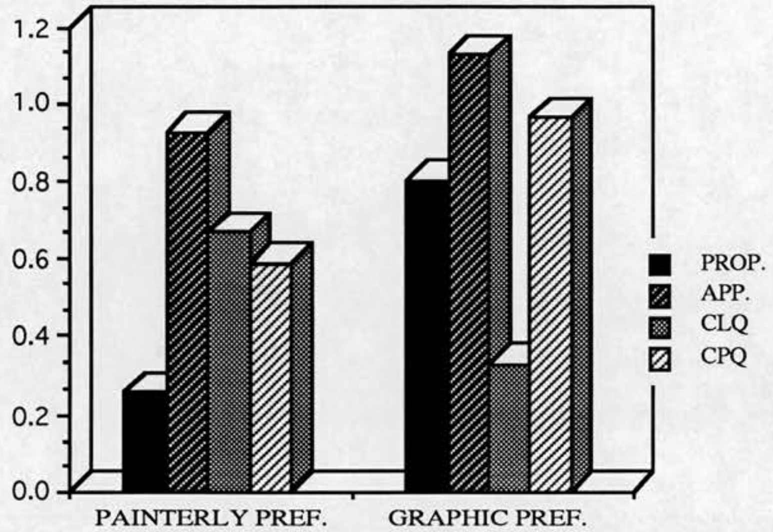


FIGURE TWENTY-TWO : BAR CHART OF PROPOSITIONAL, APPOSITIONAL, CLQ, AND CPQ SCORES FOR THE PAINTERLY/GRAPHIC PREFERENCE GROUPS

Figure Twenty-two shows that the final four values of the CLB differentiate quite clearly between the two groups: perhaps the most obvious difference is shown by the Propositional score, where the Graphic preference group (mean=.800) is clearly superior to the Painterly preference group (mean=.255), although both values comfortably exceed the norm. It is interesting to note that the CLQ, the index of Right hemisphericity according to Gordon, shows a much higher value for the Painterly group, indicating that the Graphic preference group were more left hemisphere, Propositional dominant, as predicted.

Analysis of Variance Table				
Source:	**DF:**	**Sum Squares:**	**Mean Square:**	**F-test:**
Between groups	1	1.350	1.350	3.651
Within groups	40	14.788	.370	p = .0632
Total	41	16.137		

TABLE THIRTY-TWO : ANOVA ON CPQ SCORE FOR PAINTERLY/GRAPHIC GROUPS

An ANOVA of the overall CPQ does not reveal a significant F-value [**TABLE THIRTY-TWO**]; however, such are the differences seen in the descriptive statistics, it was thought worthwhile to carry out pairwise comparisons [**TABLE THIRTY-THREE**]:

Serial Sounds score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
40	2.207	.0166		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
GRAPHIC	27	.798	1.166	.224
PAINTERLY	15	.010	.998	.258

Word Production-Letters score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
40	1.827	.0376		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
GRAPHIC	27	.898	.971	.187
PAINTERLY	15	.263	1.257	.325
Form Completion score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
40	1.727	.046		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
GRAPHIC	27	1.032	.889	.171
PAINTERLY	15	.540	.876	.226
Propositional score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
40	2.142	.0192		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
GRAPHIC	27	.800	.760	.146
PAINTERLY	15	.255	.840	.217
CPQ-Cognitive score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
40	1.911	.0316		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
GRAPHIC	27	.964	.611	.118
PAINTERLY	15	.590	.602	.155

TABLE THIRTY-THREE: CLB SCORES FOR GRAPHIC/PAINTERLY PREFERENCE-T-TESTS

Although the CLQ appeared to differ quite strongly between the groups, it was found that the difference was not strong enough to register as statistically significant. Relatively low numbers in the sample contributed to the lack of significance in the ANOVA-the t-tests certainly encourage continued faith in the hypothesis that the Graphic preference group would score more highly than the Painterly group in any larger sample.

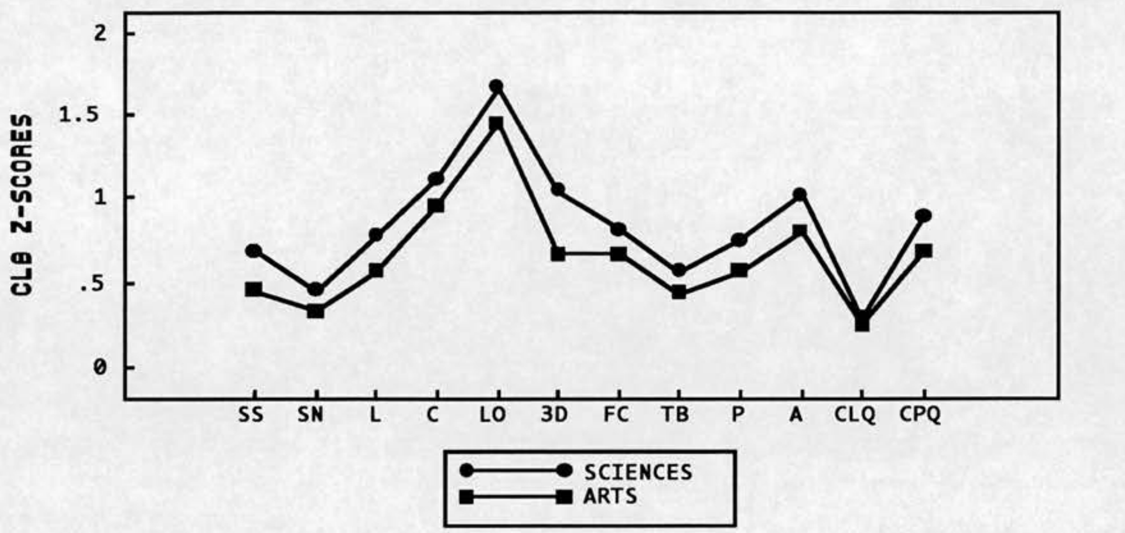


FIGURE TWENTY -THREE: COMPARISON BETWEEN CLB SCORES FOR SCIENCE AND ARTS STUDENT GROUPS

Comparisons between the CLB values for Science and Arts students [**FIGURE TWENTY-THREE**] show the general superiority of the Science group on this cognitive test.

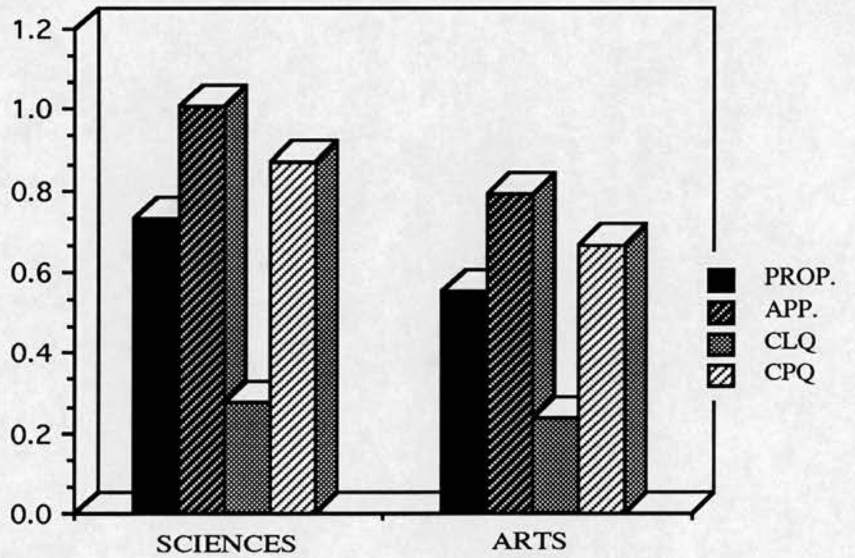


FIGURE TWENTY-FOUR: BAR CHART COMPARISON BETWEEN PROPOSITIONAL, APPOSITIONAL, CLQ, AND CPQ SCORES ON THE CLB FOR ARTS AND SCIENCES STUDENTS

If the last four values are compared for the two groups [**FIGURE TWENTY-FOUR**] it may be seen that both Appositional and Propositional values are greater for the Science students, with the Appositional being the more striking of the value differences.

Analysis of Variance Table				
Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	1.197	1.197	4.671
Within groups	120	30.740	.256	p = .0327
Total	121	31.937		

TABLE THIRTY-FOUR: ANOVA ON CPQ SCORES FOR ARTS AND SCIENCES STUDENTS

An ANOVA was carried out on the CPQ scores for both groups [**TABLE THIRTY-FOUR**]; as this proved significant (p=.0327) pairwise comparisons were examined[**TABLE THIRTY-FIVE**]:

3d Spatial Rotation score				
DF:	Unpaired t Value:	Prob. (1-tail):		
120	-2.146	.017		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
ARTS	59	.652	.939	.122
SCIENCES	63	1.027	.984	.124
Appositional score				
DF:	Unpaired t Value:	Prob. (1-tail):		
120	-1.9	.0299		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
ARTS	59	.788	.689	.090
SCIENCES	63	1.006	.577	.073
CPQ-Cognitive score				
DF:	Unpaired t Value:	Prob. (1-tail):		
120	-2.161	.0163		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
ARTS	59	.669	.532	.069
SCIENCES	63	.867	.481	.061

TABLE THIRTY-FIVE: CLB SCORES FOR CULTURE-ARTS/SCIENCES-T-TESTS

The weight of the significant differences between these two groups was, indeed, to be found in the Appositional area, most heavily with the 3d Rotation sub-test, the Science group (mean=1.027) significantly outscoring the Arts group (mean=.652). As the Arts group was not wholly composed of visual arts students but included those from Literature and History together with other disciplinary areas it is not surprising the expected higher Appositional scores did not materialise. The Sciences clearly require right hemisphere skills, too.

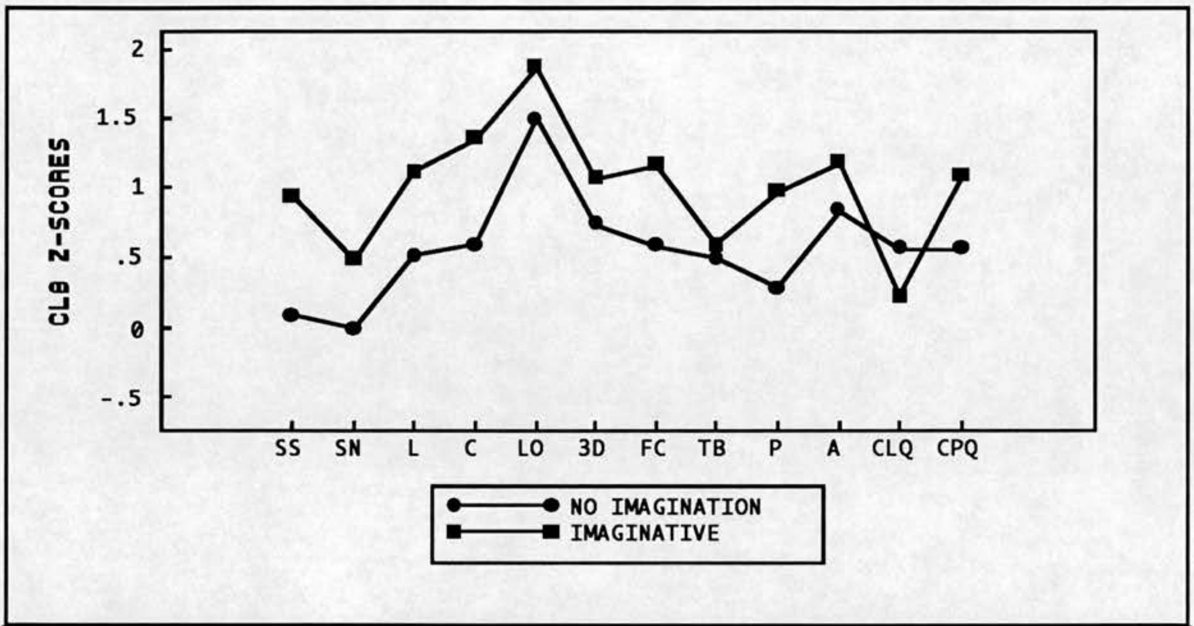


FIGURE TWENTY-FIVE: COMPARISON OF CLB SCORES FOR THOSE WHO CLAIM IMAGINATIVE DRAWING ABILITY AGAINST THOSE WHO ADMIT NONE

Once more the comparison of CLB values [**FIGURE TWENTY-FIVE**] between two category groups shows what appear to be very strong differences, the Imaginative group superior overall.

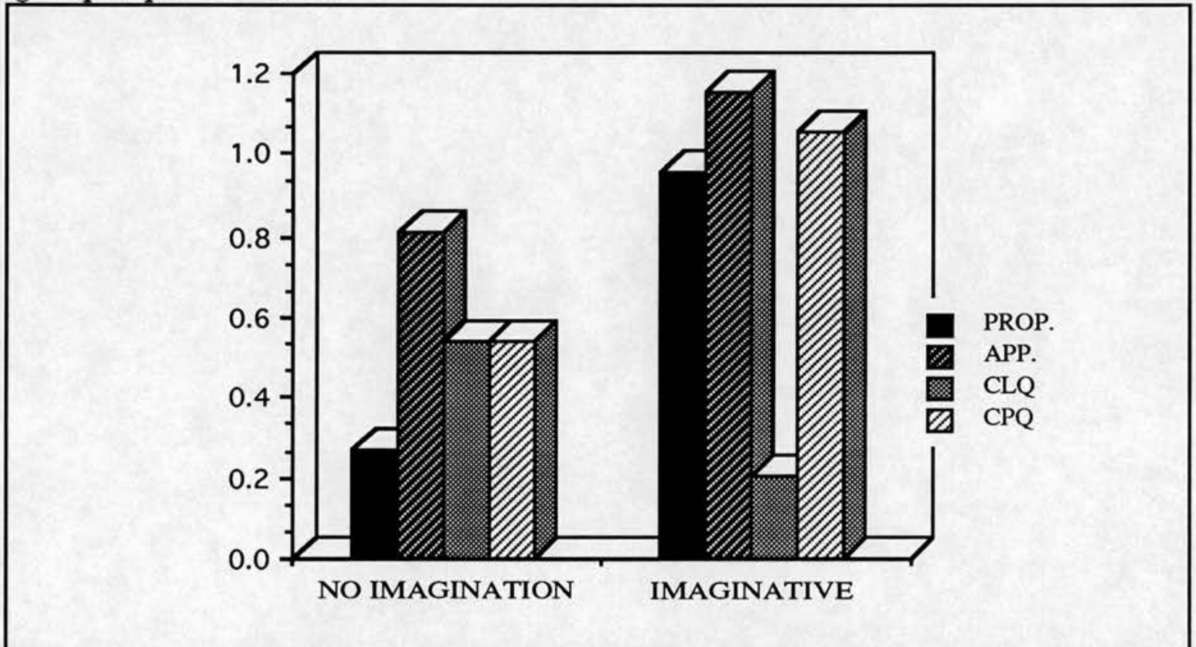


FIGURE TWENTY-SIX : BAR CHART COMPARISON OF PROPOSITIONAL, APPOSITIONAL, CLQ, CPQ SCORES FOR THE IMAGINATIVE/NON-IMAGINATIVE;

Very large differences between both Propositional and Appositional scores are indicated by the bar chart of the final four values of the CLB [**FIGURE TWENTY-SIX**]; greatest difference seems to be in the Propositional scores, however.

Analysis of Variance Table				
Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	1	2.181	2.181	6.583
Within groups	34	11.265	.331	p = .0149
Total	35	13.446		

TABLE THIRTY-SIX : ANOVA ON CPQ SCORES FOR IMAGINATIVE/NON-IMAGINATIVE

Table Thirty-six shows that the CLB as a whole produces a significant difference (p=.0149) between the Imaginative/Non-imaginative groups. Pairwise comparisons by t-test are shown in **Table Thirty-seven**:

Serial Sounds score				
DF:	Unpaired t Value:	Prob. (2-tail):		
34	2.282	.0289		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
YES	23	.922	1.034	.216
NO	13	.082	1.108	.307
Word Production-Categories score				
DF:	Unpaired t Value:	Prob. (1-tail):		
34	2.169	.0186		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
YES	23	1.332	1.115	.233
NO	13	.575	.770	.214
Propositional score				
DF:	Unpaired t Value:	Prob. (1-tail):		
34	2.463	.0095		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
YES	23	.955	.849	.177
NO	13	.273	.695	.193
CPQ-Cognitive score				
DF:	Unpaired t Value:	Prob. (1-tail):		

34	2.566	.0074		
Group:	Count:	Mean:	Std. Dev.:	Std. Error:
YES	23	1.056	.512	.107
NO	13	.543	.676	.188

TABLE THIRTY-SEVEN: CLB SCORES FOR IMAGINATIVE DRAWING ABILITY-T-TESTS

In contrast to the preceding category, where the Appositional scoring proved most decisive in separating the groups, with the Imaginative/Non-imaginative subjects it was the Propositional scores which best discriminated between them (Imaginative mean=.955, Non-imaginative mean=.273), as had been suggested by the bar chart. Those who are able to "draw from their heads" and do not rely almost solely on replicating real life are superior scorers on the CLB across the board, over all the sub-tests; however, this only became significant in the verbal-sequential tests. It may be in order to conclude that imagination-in this case, visual imagination-is something which depends on "left hemisphere" abilities more than on "right hemisphere" abilities. It may be that there are two sorts of imagination: a "fantastic" imagination and an aesthetic one, the former to be found among those abilities conventionally identified as left hemisphere, and the latter having a greater emotional content and therefore deriving from the right hemisphere and its limbic connections.

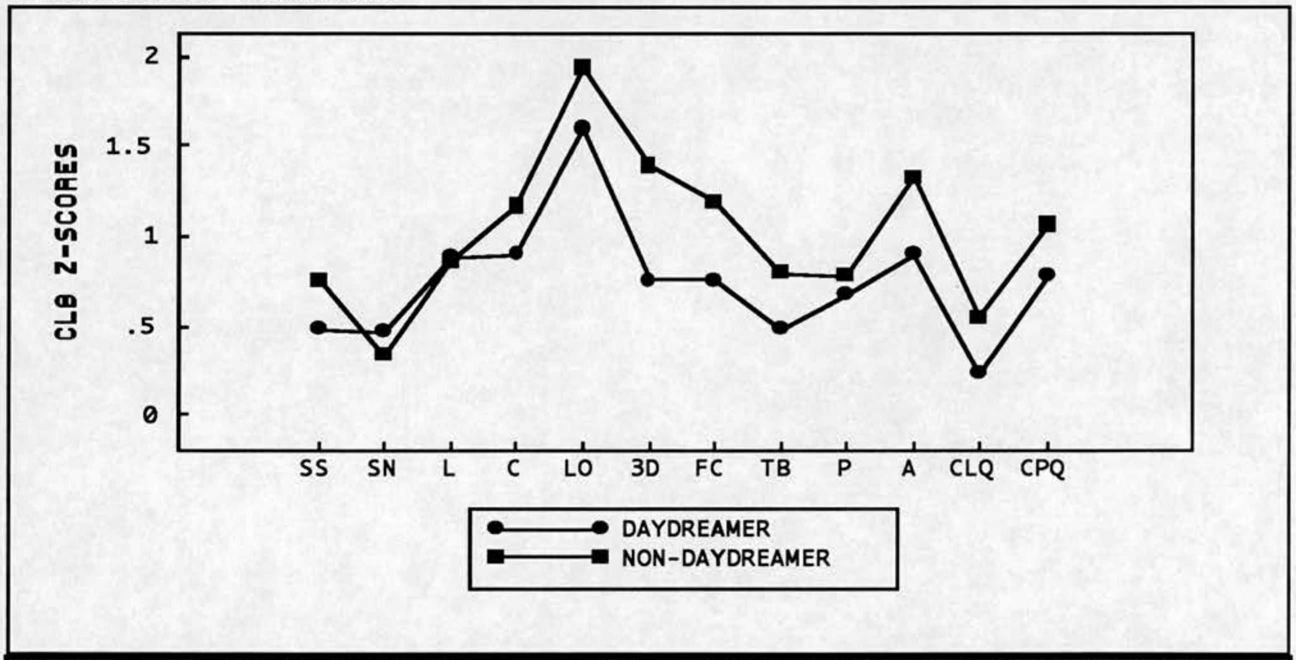


FIGURE TWENTY-SEVEN : COMPARISON BETWEEN CLB SCORES FOR DAYDREAM/NON-DAYDREAM GROUPS

The next category to be examined is that of Daydreaming; comparisons between the 12 values of the CLB for the two groups Daydreamers/Non-daydreamers show that, in general terms, it is the Non-daydreamers who score best [**FIGURE TWENTY-SEVEN**]. To render the scores in more immediately obvious form, the following bar-graph [**FIGURE TWENTY-EIGHT**] was produced, which clearly shows the differences between the two groups, those who say they deep daydream and those who say they do not:

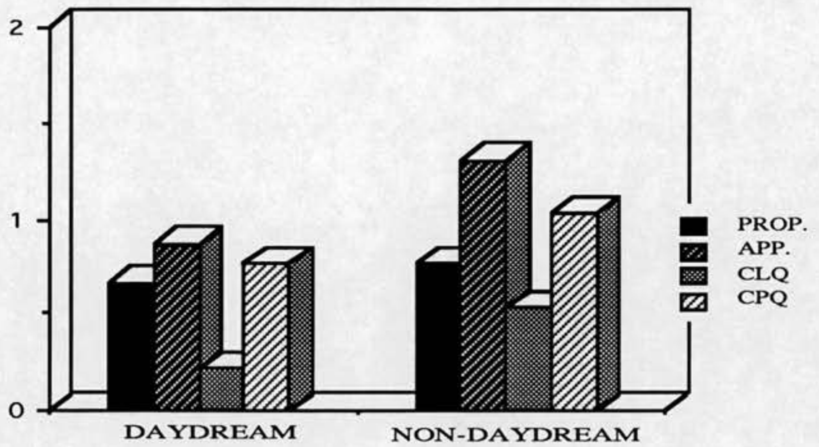


FIGURE TWENTY-EIGHT: BAR CHART COMPARISON BETWEEN PROPOSITIONAL, APPOSITIONAL, CLQ, AND CPQ SCORES FOR DAYDREAM/NON-DAYDREAM GROUPS

A One-Way ANOVA was marginally non-significant on the CPQ scores of the Daydreamer variable, although the graph of the sub-test scores [above] appeared interesting; accordingly, a series of t-tests were carried out using this intriguing variable [**TABLE THIRTY-EIGHT**]:

3d Spatial Rotation score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
52	-2.491	.008		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	31	.739	.874	.157
NO	23	1.367	.972	.203
Form Completion score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
52	-1.69	.0485		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	31	.748	.961	.173
NO	23	1.169	.823	.172
Touching Blocks score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
52	-1.707	.0469		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	31	.473	.772	.139

NO	23	.777	.427	.089
Appositional score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
52	-2.466	.0085		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	31	.883	.669	.120
NO	23	1.306	.556	.116
CPQ-Cognitive score				
DF:	**Unpaired t Value:**	**Prob. (1-tail):**		
52	-1.754	.0427		
Group:	**Count:**	**Mean:**	**Std. Dev.:**	**Std. Error:**
YES	31	.774	.561	.101
NO	23	1.037	.519	.108

TABLE THIRTY-EIGHT: CLB SCORES FOR DAYDREAMING-T-TESTS

All the sub-tests showed an advantage for those individuals who did not daydream deeply, although the greatest advantage was to be found in the Appositional sub-tests (mean difference=.423), three out of the four showing significantly different scores between the two groups, the greatest difference between means being that for 3d Rotation (.628). This may lead to the conclusion that non-daydreamers are more concrete, "down-to-earth", more tied to the real world, if the external world, visual-spatial nature of the faculties conventionally identified with right hemisphere functioning are considered. There is a difference in the mean CPQ scores of the two groups of .263.

MULTIPLE CATEGORY COMPARISONS

If some of the various categories which have proved most strongly discriminatory between groups (Mathematical ability. Imaginative drawing, Daydreaming) are used together to examine the CPQ scores, the following ANOVA is the result [**TABLE THIRTY-NINE**]:

Source:	**Degrees of Freedom**	**Sum of Squares:**	**Mean Square:**	**F-test:**	**P value:**
MATH ABILITY (A)	1	4.103	4.103	17.303	.0003
IMAG. DRAW. (B)	1	2.185	2.185	9.214	.0051
AB	1	.475	.475	2.003	.168
DAYDREAM (C)	1	.754	.754	3.178	.0855
AC	1	.056	.056	.234	.6321
BC	1	.081	.081	.340	.5645
ABC	1	.082	.082	.344	.5621
Error	28	6.64	.237		

IMAG. DRAW.:		YES		NO		Totals:
DAYDREAMER:		YES	NO	YES	NO	
MATH AB...	YES	9 1.191	8 1.217	7 .614	3 1.124	27 1.042
	NO	3 .403	3 .872	1 -.516	2 -.048	9 .357
Totals:		12 .994	11 1.123	8 .473	5 .655	36 .871

TABLE THIRTY-NINE: THREE FACTOR ANOVA ON MATH. ABILITY, IMAGINATIVE DRAWING, AND DAYDREAMING VARIABLES WITH CPQ SCORES (significant p-values underlined)

It seems that, as the thesis would predict, a concatenation of what have been identified as deleterious factors produces steadily lowering cognitive test scores: there were main effects for Imaginative Drawing (F-value=17.303, df=1/28, p=.0003), and for Mathematical Ability (F-value=9.214, df=1/28, p=.0051) on the CPQ scores. Imaginative drawing ability and Mathematical ability together produced the highest score (1.217), while the one individual who had no Math ability, no Imaginative drawing ability, and daydreamed also scored lower than anyone else (-.516). The highest cognitive score, therefore, goes to the group with imagination, mathematical ability, and who do not deep daydream . There were no interactions in the CPQ ANOVA table; Daydreaming had a non-significant overall effect (F-test=3.178, df=1/28, p=.0855).

CROSS RELATIONSHIPS;

Daydreaming, Asthma, Reality Loss, Familial Allergy, Early Walk/ Speech, Culture, Artistic Mother, N.T.D., Early Literacy, Father Math, Math Ability

If the Somatic and Psychological characteristics are compared, some interesting relationships are found:

N	df	Phi	Chi-square	Probability	Variable		
28	1	.549	6.039	.0140	H/L CPQ groups	vs	Clumsiness`
63	1	.320	5.076	.0243	Fam. myopia	vs	Daydreaming
61	1	.302	3.879	.0489	Early walking	vs	Father mathematical
64	1	.358	5.486	.0192	Early walking	vs	Early speech
64	1	.331	5.306	.0213	Early read./writing	vs	Early speech
64	1	.295	3.941	.0471	Asthma	vs	Early read./writing
47	1	.374	4.538	.0332	Asthma	vs	NTD
65	1	.292	4.230	.0397	Familial asthma	vs	Monotalent

65	1	.358	6.667	.0098	Hair colour	vs	Father musical
63	1	.351	6.266	.0123	Myopia	vs	Doodle
65	1	.282	3.863	.0494	Child illness	vs	Antisocial

TABLE FORTY : CHI-SQUARE ASSOCIATIONS BETWEEN SOMATIC AND PSYCHOLOGICAL CHARACTERISTICS

Familial Myopia

Familial myopia produced an association with deep daydreaming: 65.22% of those who had familial myopia also had deep daydreaming, while 85.71% of daydreamers had familial myopia; only 14.29% of those without familial myopia admitted deep daydreaming.

Other categories produced associations of interest:

Early speech and early walking had a significant association: 92.59% of those who did not speak early did not walk early, either, while 40% of those who spoke early also walked early. On the whole, the odds seem against these abilities developing independently. Early command of reading and writing seems to be associated with early speech: 90% of early speakers were also early in literacy, with 96.77% of non-early readers/writers were also non-early speakers. Only 3.03% of the early literate had asthma (96.97% having early literacy did not have asthma), conversely, 12.5% of the asthmatic had early reading/writing. Presumably asthma keeps children from school. It is an odd result that there were no early walkers who had mathematical fathers, it following that all of those who walked early did not have mathematical fathers; only 21.05% of those who do not have mathematical fathers walked early. It may be correct to take this to be a statistical artefact.

Need to draw is associated with asthma: *all* of the asthmatics had a need to draw, while only 43.9% of the non-asthmatics had a similar need; 25% of those who had a need to draw were asthmatics. Could the old classic situation of the bed-ridden asthmatic, unable to do anything more strenuous than draw, inspire a life-long need to keep drawing? One is reminded of the case of Gerald Scarfe, the satirical cartoonist, who is asthmatic and says that it was exactly the situation of being bedridden by his illness as a child which started his artistic career.

Familial asthma is associated with having but the one area of ability: 58.82% of those with asthma in the family are able in only one area of skill, while 27.08% of those without familial asthma are monotalented; 43.48% of the monotalented have asthmatics in the family, with only 16.67% of the multi-skilled declaring any asthmatic relative. Such results are strongly suggestive of a hereditary influence on the monotalented, asthma perhaps causing educational problems not only in those who are prevented from having regular schooling when they suffer from the illness themselves, but also in those who inherit the genetic complex which includes a predisposition to asthma; asthma sufferers in a family which includes other asthma sufferers may then be doubly disadvantaged. According to the thesis of this research, having more than one area of skill is more "normal" than having just the one; it indicates someone whose constitution has suffered less and therefore who more closely approaches that ideal level of capability which all should share, in the best of all possible worlds.

Hair Colour

37.93% of the light-haired had musically talented fathers, while only 8.33% of the dark-haired were similarly fortunate; 78.57% of the offspring of musical fathers were light-haired, with 35.29% of the group without such talented fathers being light-haired. Nearly 13% of the variance in one variable was explained by the other. Later, it will be shown that the musician sub-group scored quite badly on the CLB relative to the other students; indirectly, the above association confirms that the musically talented family may carry "flags" or markers for relative disadvantage, such as light coloured hair.

Myopia

76.47% of the organic doodlers were myopic, while only 36.96% of the geometric doodlers were myopic; 56.67% of the myopic were geometric doodlers, with 87.88% of the non-myopic being geometric, as well. It seems that the myopic prefer doodles with biological, botanical, rounded or human-like forms to the cubes, triangles, and repetitive angular shapes of the non-myopic. This may be related to the finding that the geometric doodlers are more likely to be the mathematically able.

Multiple Regression

All those variables, both Somatic and Psychological, which produced associations in the categories and significant differences in Anovas and t-tests were used to identify the chief sources of variance in the CPQ. The first Multiple Regressions were carried out on the Somatic variables; this produced four significant variables: Allergies, Child illness, Eye colour, and Clumsiness, and an overall significant F-value for the regression ANOVA table [**TABLES FORTY AND FORTY-ONE**].

Multiple Regression COG. SCORE 4 X variables

Count:	R:	R-squared:	Adj. R-squared:	RMS Residual:
54	.575	.33	.275	.472

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	4	5.373	1.343	6.038
RESIDUAL	49	10.899	.222	p = .0005
TOTAL	53	16.272		

TABLE FORTY-ONE: REGRESSION ON COGNITIVE SCORE (CPQ) FOR ALLERGIES, CHILD ILLNESS, EYE COLOUR, AND CLUMSINESS

Beta Coefficient Table

Variable:	Coefficient:	Std. Err.:	Std. Coeff.:	t-Value:	Probability:
INTERCEPT	-.321				
ALLERGIES	-.341	.137	-.31	2.484	.0165
CHILD ILL.	.356	.164	.27	2.171	.0348
EYE COLOUR	.399	.139	.347	2.874	.006
CLUMSY	.32	.143	.271	2.236	.0299

Confidence Intervals and Partial F Table

Variable:	95% Lower:	95% Upper:	90% Lower:	90% Upper:	Partial F:
INTERCEPT					
ALLERGIES	-.616	-.065	-.571	-.111	6.17
CHILD ILL.	.026	.686	.081	.631	4.714
EYE COLOUR	.12	.678	.166	.632	8.259
CLUMSY	.032	.608	.08	.56	5.001

TABLE FORTY-TWO: BETA COEFFICIENT AND PARTIAL F VALUE TABLE FOR COGNITIVE SCORE (CPQ) ON ALLERGIES, CHILD ILLNESS, EYE COLOUR, AND CLUMSINESS

It seems clear that these regressions have identified the most important Somatic variables, between them explaining between 27% and 33% of the variance in the overall cognitive scores.

The same procedure was followed for the Psychological characteristics [**TABLE FORTY-THREE**].

88% to 96% of the CPQs were explained by 13 variables, many of them the same 'artistic' ones as those identified for the CLQ , testifying, perhaps, to the influence of the large art student group in the sample.

Multiple Regression **COG. SCORE 13 X variables**

Count:	R:	R-squared:	Adj. R-squared:	RMS Residual:
20	.981	.962	.88	.192

Analysis of Variance Table

Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	13	5.623	.433	11.717
RESIDUAL	6	.221	.037	p = .0032
TOTAL	19	5.845		

TABLE FORTY-THREE: REGRESSION ON COGNITIVE SCORE (CPQ) FOR 13 VARIABLES

The variables which do not have a significant t-value, Doodle, Reading and Writing early, and Graphic/Painting preference, had to be included because without them the others lose much significance-in multiple regressions the variables interact in a matrix [**TABLE FORTY-FOUR**].

Variable:	Coefficient:	Std. Err.:	Std. Coeff.:	t-Value:	Probability:
INTERCEPT	.694				
MONOTALENT	-1.451	.433	-.805	3.349	.0154
COLOUR/BW.	.982	.306	.89	3.207	.0184
EARLY PERSP.	-1.163	.278	-1.07	4.189	.0058
ANTISOCIAL	.901	.259	.795	3.478	.0132
REAL./ABST.	-.716	.228	-.632	3.136	.0202
DOODLE	-.336	.179	-.285	1.883	.1086
CULTURE	.34	.14	.308	2.426	.0514
MUS. M.	-1.036	.26	-.879	3.983	.0073
N.T.D.	.811	.274	.716	2.957	.0254
MUSICAL ABILI...	1.448	.538	.957	2.693	.0359
PREF. ART	.278	.265	.235	1.046	.3358
DAYDREAMER	.566	.142	.524	3.982	.0073
R./W. EARLY	.205	.118	.186	1.74	.1324

Beta Coefficient Table

Variable:	95% Lower:	95% Upper:	90% Lower:	90% Upper:	Partial F:
INTERCEPT					
MONOTALENT	-2.511	-.391	-2.293	-.609	11.213
COLOUR/BW.	.233	1.732	.387	1.578	10.288
EARLY PERSP.	-1.842	-.484	-1.703	-.623	17.547
ANTISOCIAL	.267	1.535	.398	1.405	12.097
REAL./ABST.	-1.275	-.157	-1.16	-.272	9.832
DOODLE	-.774	.101	-.684	.011	3.547
CULTURE	-.003	.682	.068	.612	5.886
MUS. M.	-1.673	-.4	-1.542	-.531	15.866
N.T.D.	.14	1.482	.278	1.344	8.745
MUSICAL ABILI...	.132	2.764	.403	2.493	7.252
PREF. ART	-.372	.927	-.238	.793	1.094
DAYDREAMER	.218	.915	.29	.843	15.856
R./W. EARLY	-.083	.494	-.024	.435	3.029

Confidence Intervals and Partial F Table

TABLE FORTY-FOUR: BETA COEFFICIENT AND PARTIAL F VALUES FOR COGNITIVE SCORES (CPQ) ON 13 VARIABLES

THUMB-NAIL SKETCHES;

If the entirety of the statistical analysis is considered, t-tests, ANOVAs and Regressions, certain preliminary conclusions can be drawn. As the CPQ score is an estimate of cognitive ability, some judgements may be made on which variables are helpful and which are deleterious to this description of intelligence. The worst possible case would be for a light-haired, light-eyed individual, possibly female, possibly right-handed, born in the Northern Hemisphere in February, March, April, or May, with either a musical or artistic mother, who daydreams deeply but who cannot draw imaginatively, and prefers realistic paintings to drawings, although her grasp of perspective is still not good; she would have asthma in the family and may have been ill herself quite often as a child, but does not suffer from allergies; she was clumsy then and perhaps still is. She belongs to an Arts discipline, and is not very good at mathematics, probably not learning how to read or write early, either. This person is likely to have the lowest score on the CLB Cognitive Performance Quotient.

The best case scenario is for a dark haired, dark eyed individual, possibly male, possibly left-handed, born in the Northern Hemisphere in any months other than February, March, April, or May, whose mother is not musical or artistic (but whose father could be skilled in math); he is not a daydreamer, is able to produce imaginative line drawings showing a good grasp of perspective, which he has had since early childhood; he prefers that sort of art, or sometimes abstract pieces. He is good at math, and belongs to a Science discipline; an early reader and writer, he was a very healthy child, never away from school for long, agile, but does suffer from allergies, although there is no asthma in the family. This person is likely to have the highest score on the CLB Cognitive Performance Quotient.

HANDEDNESS: DIFFERENCES BETWEEN APPOSITIONAL AND PROPOSITIONAL SCORES {LEVY REVISITED}

As Levy (1970) found significantly greater differences ($p<.0002$, $N=25$) between the Wechsler Intelligence Test Verbal and Performance scores of left-handers as compared with the scores of right-handers,[418] it was thought useful to look at the scores on the two sets of sub-tests in the CLB, the Propositional (comparable with the Wechsler Verbal tests) and the Appositional (comparable with the Wechsler Performance tests) as performed by the right- ($N=105$) and left- ($N=17$) handers in the sample. Left-handers were a higher proportion of the sample than expected: 14%. For the right-handers, all but the Form Completion versus Word Production-Letters sub-tests were significantly different, using a two-tailed paired t-test; when Propositional right-handed scores were compared with Appositional right-handed scores, the overall difference was again significant **[TABLE FORTY-FIVE]**:

DF:	Mean X - Y:	Paired t value:	Prob. (1-tail):
105	-.227	-2.718	.0039

TABLE FORTY-FIVE: PAIRED T-TEST BETWEEN PROPOSITIONAL AND APPOSITIONAL SCORES FOR RIGHT-HANDERS ONLY

If the histograms are studied **[FIGURES TWENTY-NINE TO THIRTY-TWO]**it may be seen that there were more right-handed low scorers on the Propositional sub-tests, but

[418] Levy, J., Information Processing and Higher Psychological Functions in the Disconnected Hemispheres of Human Commisurotomy Patients, PhD Thesis, California Institute of Technology, 84-90, 1970.

more high scorers on the Appositional sub-tests. When the left-handers' scores for Propositional versus Appositional performance were compared, there was a significant difference [**TABLE FORTY-SIX**]:

DF:	Mean X - Y:	Paired t value:	Prob. (1-tail):
17	-.529	-3.295	.0021

TABLE FORTY-SIX: PAIRED T-TEST BETWEEN PROPOSITIONAL AND APPOSITIONAL SCORES FOR LEFT-HANDERS ONLY

If the histograms of **Figures Twenty-nine** to **Thirty-two** are studied, it may be seen that the distributions are somewhat negatively skewed, to the right from 0, indicating that this is quite an able sample, overall.

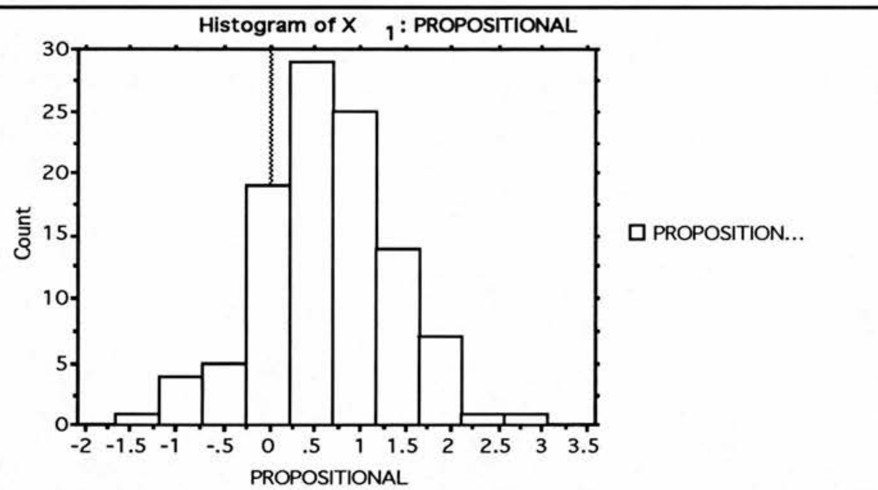


FIGURE TWENTY-NINE: COGNITIVE LATERALITY BATTERY: RIGHT-HANDERS-PROPOSITIONAL

The greatest number of below-norm scores are to be found in the left-handers and their Propositional histogram [**FIGURE THIRTY-ONE**].

It may be remembered that these are likely to be the left-handers who suffer from asthma

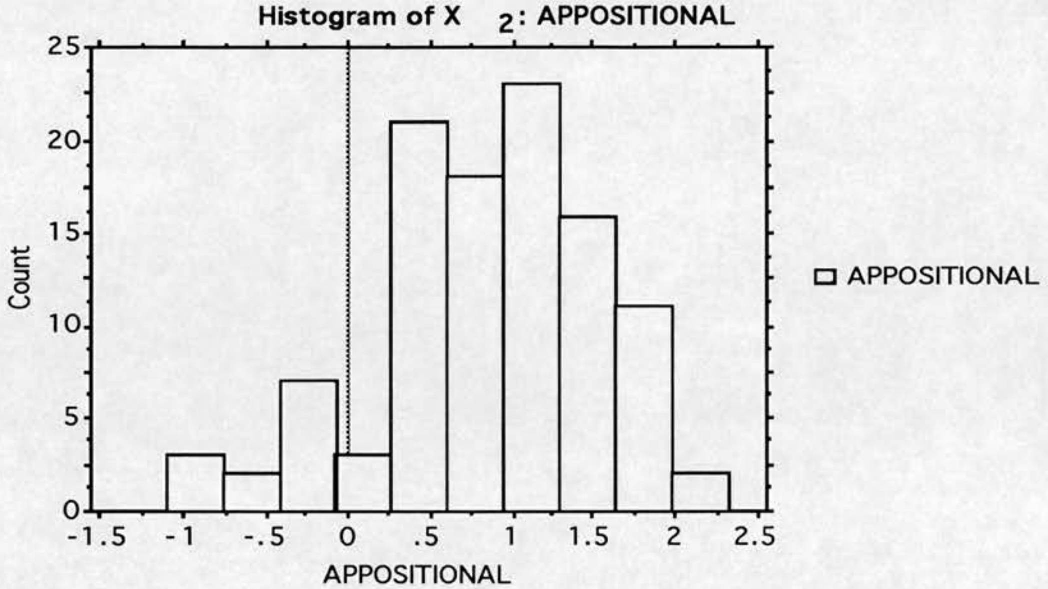


FIGURE THIRTY: COGNITIVE LATERALITY BATTERY: RIGHT-HANDERS-APPOSITIONAL

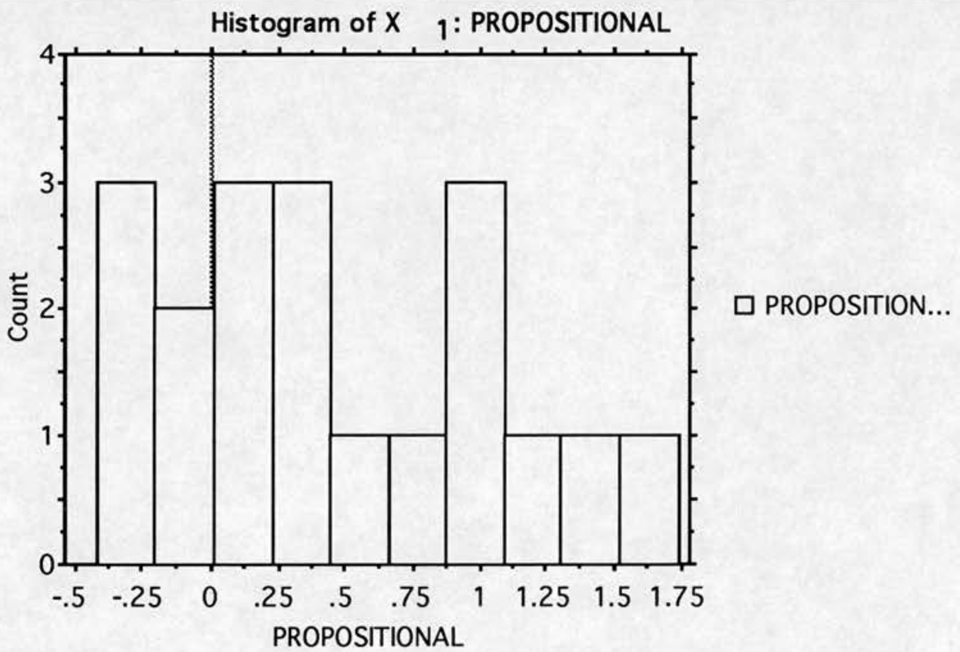


FIGURE THIRTY-ONE: COGNITIVE LATERALITY BATTERY: LEFT-HANDERS-PROPOSITIONAL

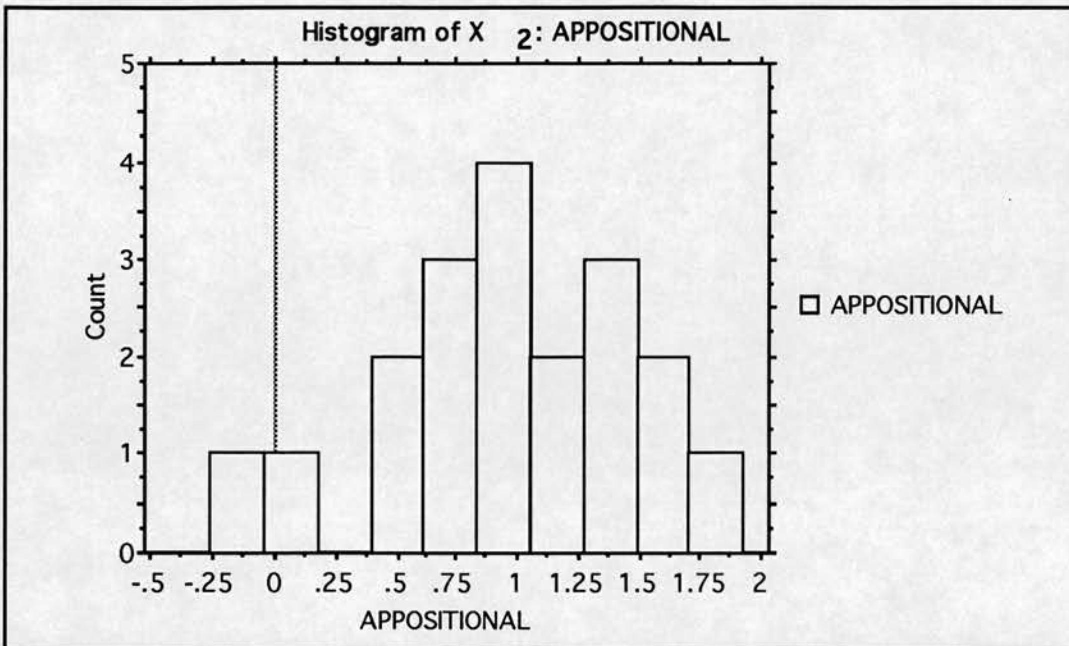


FIGURE THIRTY-TWO: COGNITIVE LATERALITY BATTERY: LEFT-HANDERS-APPOSITIONAL

Looking at the histograms it may be noticed that the pattern of more high scoring on the Appositional and less high scoring on the Propositional sub-tests is the same as that shown by the right-handers; however, the difference between the two hands was in performance on the Propositional sub-tests: there seems to be nearly twice as great a difference between the high and low scoring Propositional scores in the case of the left-handers. There are no left-handers beyond 1.75, while there are right-handers who reach 3.00.

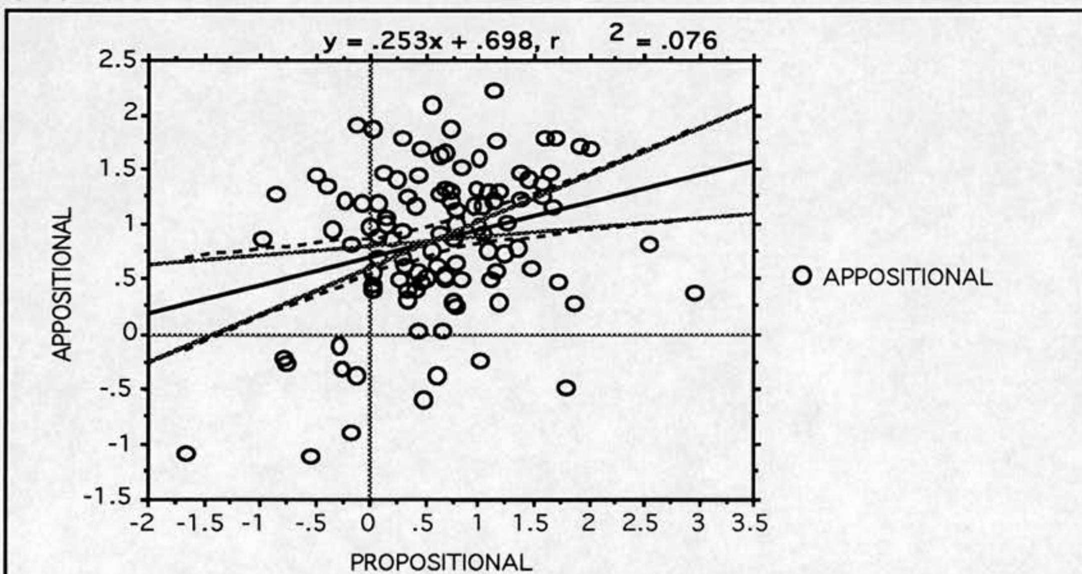


FIGURE THIRTY-THREE: REGRESSION ON APPOSITIONAL SCORES VERSUS PROPOSITIONAL SCORES FOR RIGHT-HANDERS ONLY

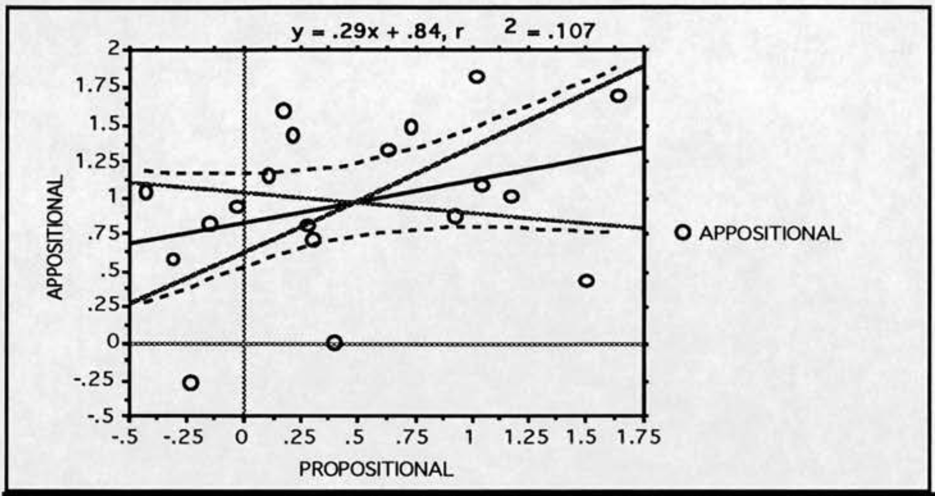


FIGURE THIRTY-FOUR: REGRESSION ON APPOSITIONAL SCORES VERSUS PROPOSITIONAL SCORES ON LEFT-HANDERS ONLY

If the two Regression graphs are studied [**FIGURES THIRTY-THREE AND THIRTY-FOUR**], they provide pictorial evidence of the wider "band-width" of the left-handers over the right-handers; the lines of 95% certainty are further apart for the left-handers, tighter for the right-handers. It may be concluded that there was a moderate semi-replication of Levy's findings, in that the difference between Propositional and Appositional scores for the left-handers was, indeed, greater than that found between the same two scores by the right-handers, to a mean difference of .302, equivalent to .0018 on the p-value, or increasing the t-value by .577.

SUB-GROUP COMPARISONS/ARTISTS, MUSICIANS, MATHEMATICIANS, DYSLEXICS

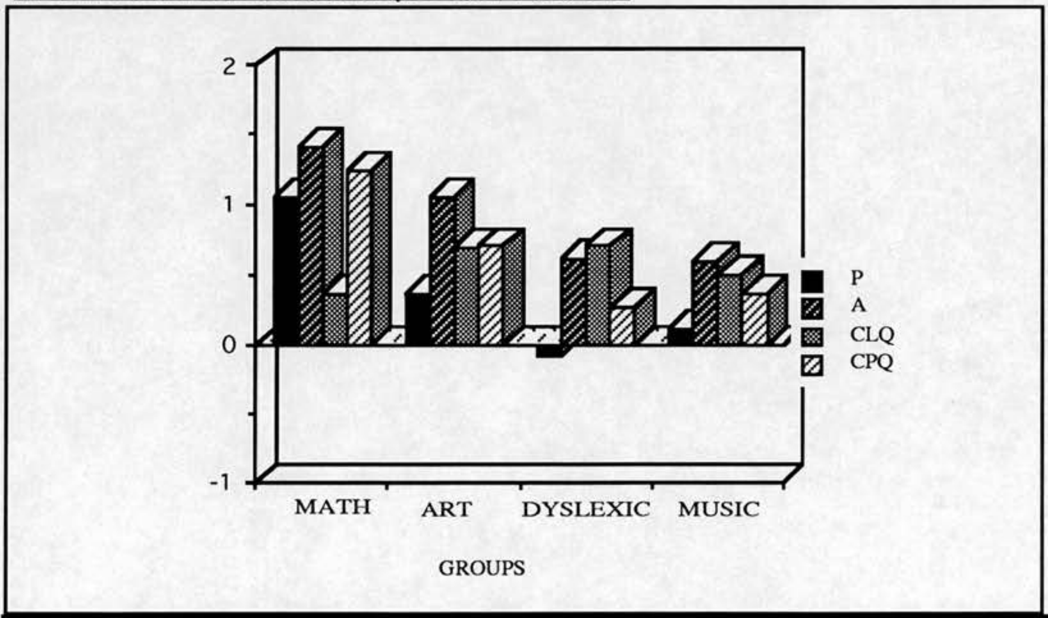


FIGURE THIRTY-FIVE: BAR CHART COMPARISON BETWEEN MATH, ART, AND MUSIC STUDENTS, TOGETHER WITH THE DYSLEXIC SUB-GROUP

It can be seen from the 3d bar chart that the Propositional scores for the four groups reduce in the order Math, Art, Music, and Dyslexic; the Appositional scores reduce in the order Math, Art, with the musicians and dyslexics almost even; CLQ scores reduce in the order Dyslexic, Art, Music, Math; CPQ scores reduce in the order Math, Art, Music, Dyslexic [**FIGURE THIRTY-FIVE**].
Inferential statistical analysis was carried out on the scores on the CLB of the four sub-groups of Musicians, Artists, Mathematicians, and Dyslexics, in order to ascertain which groups resembled each other or differed from each other, and in which ways. Only Form Completion out of all the sub-tests of the CLB will be examined in detail; its particular interest lies in the unexpectedly good performance by the dyslexics.
As in **Graph Thirty-two**, the last four of the CLB values then will be analysed.

FORM COMPLETION
Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	3	13.71	4.57	8.133
Within groups	41	23.038	.562	p = .0002
Total	44	36.748		

TABLE FORTY-SEVEN: ANOVA ON FORM COMPLETION SCORES

The ANOVA was significant (F-test=8.133, df=3/44, p<.0005), suggesting significant differences between the groups [**TABLE FORTY-SEVEN**]. When the post hoc pairwise comparisons between sub-groups are made these differences emerge very clearly [**TABLE FORTY-EIGHT**].

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
MUSIC vs. ART	-1.073	.627*	3.988*	3.459
MUSIC vs. DYSLEXIC	-1.662	.746*	6.748*	4.499
MUSIC vs. MATH	-1.209	.627*	5.056*	3.895
ART vs. DYSLEXIC	-.589	.701	.959	1.696
ART vs. MATH	-.135	.572	.076	.477

* Significant at 95%

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
DYSLEXIC vs. MATH	-1.566	1.016*	3.231*	3.114

* Significant at 95%

TABLE FORTY-EIGHT FORM COMPLETION POST HOC SUB-GROUP COMPARISONS AND SIGNIFICANCES

Significant pairwise comparisons in **Table Forty-eight** are:

1) musicians versus artists (mean difference=-1.073, $p<.05$)
2) musicians versus dyslexics (mean difference=-1.662, $p<.05$)
3) musicians versus mathematicians (mean difference=-1.209, $p<.05$)
4) dyslexics versus mathematicians (mean difference=-1.566, $p<.05$)

It may be noted that in this instance it is the **dyslexics** who outscore everyone by a very wide margin, even the mathematicians. All these four pairwise comparisons are therefore significantly different in favour of the dyslexics. In every other sub-test the dyslexics scored least well of the groups. All other 1 Way ANOVAs were significant except that for Serial Numbers.

PROPOSITIONAL

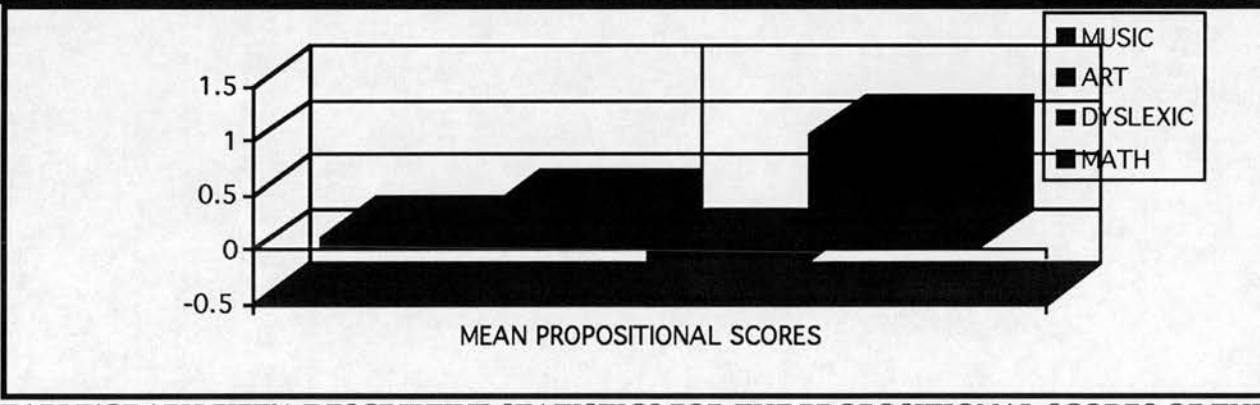
Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	3	8.251	2.75	5.902
Within groups	41	19.107	.466	p = .0019
Total	44	27.357		

TABLE FORTY-NINE: ANOVA ON PROPOSITIONAL SCORES AND SUB-GROUP COMPARISONS

The ANOVA for the four Propositional sub-tests was significant (F-test=5.902, df=3/44, $p<.002$) [**TABLE FORTY-NINE**], and so some of the pairwise comparisons were significant as well: musicians versus mathematicians (mean difference=-.936, $p<.05$); artists versus mathematicians (mean difference=-.688, $p<.05$); dyslexics versus mathematicians (mean difference= -1.131, $p<.05$) [**TABLE FIFTY**].

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
MUSIC	10	.11	.93	.294
ART	14	.359	.731	.195
DYSLEXIC	7	-.085	.259	.098
MATH	14	1.046	.554	.148



TABLE/GRAPH FIFTY: DESCRIPTIVE STATISTICS FOR THE PROPOSITIONAL SCORES OF THE FOUR SUB-GROUPS

It may be seen [**TABLE FIFTY**] that the standard deviations of at least two of the sub-group scores are too large for much trust to be placed in any analysis based upon them.

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
MUSIC vs. ART	-.248	.571	.257	.879
MUSIC vs. DYSLEXIC	.195	.679	.112	.579
MUSIC vs. MATH	-.936	.571*	3.657*	3.312
ART vs. DYSLEXIC	.443	.638	.656	1.402
ART vs. MATH	-.688	.521*	2.369	2.666

* Significant at 95%

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
DYSLEXIC vs. MATH	-1.131	.638*	4.269*	3.579

* Significant at 95%

TABLE FIFTY-ONE: PROPOSITIONAL SCORES POST HOC SUB-GROUP COMPARISONS AND SIGNIFICANT DIFFERENCES

Although the significant differences have been noted, the same doubts about the nature of the wide amount of variance in the scores as has already been expressed would tend to cast doubt on their validity, as well.

APPOSITIONAL
Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	3	5.068	1.689	5.126
Within groups	41	13.51	.33	p = .0042
Total	44	18.578		

TABLE FIFTY-TWO: APPOSITIONAL SCORES COMPARISONS BETWEEN SUB-GROUPS

The ANOVA was significant (F-test=5.126, df=3/44, p<.005) [**TABLE FIFTY-TWO**], giving two of the pairwise comparisons significance as well: musicians versus mathematicians (mean difference= -.812, p<.05), and dyslexics versus mathematicians (mean difference=-.803, p<.05) [**TABLE FIFTY-THREE**].

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
MUSIC	10	.601	.775	.245
ART	14	1.042	.403	.108
DYSLEXIC	7	.609	.611	.231
MATH	14	1.413	.538	.144

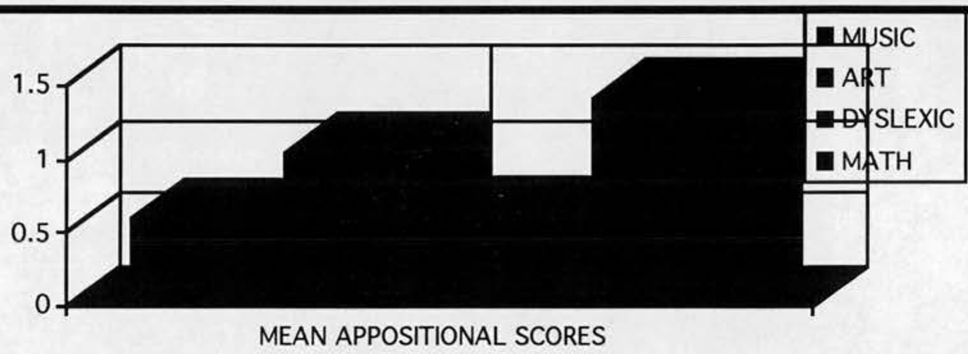


TABLE /GRAPH FIFTY-THREE: DESCRIPTIVE STATISTICS FOR THE APPOSITIONAL SCORES FOR THE FOUR SUB-GROUPS

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
MUSIC vs. ART	-.441	.48	1.149	1.856
MUSIC vs. DYSLEXIC	-.008	.571	2.889E-4	.029
MUSIC vs. MATH	-.812	.48*	3.888*	3.415
ART vs. DYSLEXIC	.433	.537	.884	1.629
ART vs. MATH	-.371	.438	.972	1.708

* Significant at 95%

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
DYSLEXIC vs. MATH	-.803	.537*	3.047*	3.023

* Significant at 95%

TABLE FIFTY-FOUR: APPOSITIONAL SCORES POST HOC COMPARISONS BETWEEN SUB-GROUPS

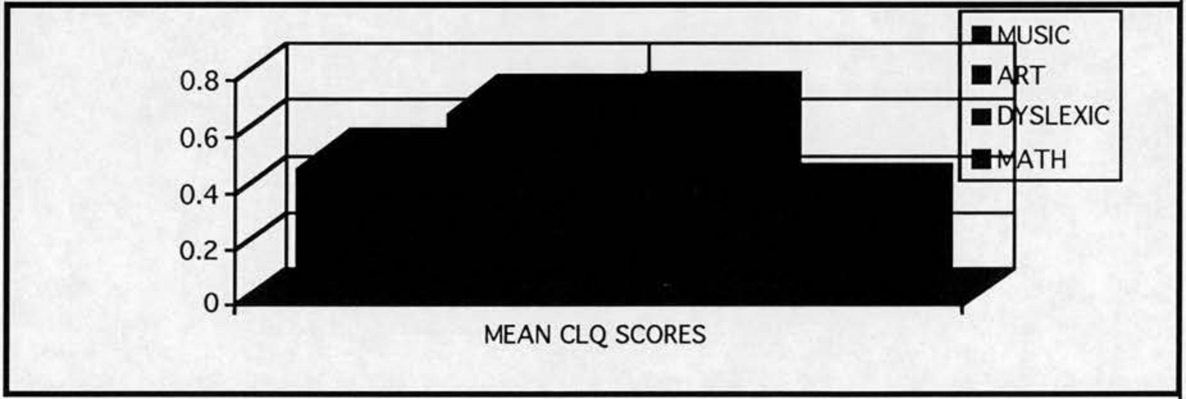
CLQ
Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	3	.9	.3	.522
Within groups	41	23.56	.575	p = .6694
Total	44	24.46		

TABLE FIFTY-FIVE: ANOVA ON COGNITIVE LATERALITY QUOTIENT SCORES SUB-GROUP COMPARISONS

The **ANOVA** was not significant [**TABLE FIFTY-FIVE**], leaving none of the pairwise comparisons significant, either. From the figures in the table [**TABLE FIFTY-FOUR**] it may be seen that the dyslexics were the most "right hemisphere" group, followed by the artists, then the musicians, and the most "left hemisphere" group were the mathematicians. Some high scoring on the Appositional tests made scores on the CLQ all fall in the "right hemisphere", positive number side, so that differences appeared to be rather how more or less a group was "right hemisphere" than which were "left" or "right". This masked the Propositional advantage of some groups, such as the mathematicians, and to a much lesser extent, the artists.

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
MUSIC	10	.491	.854	.27
ART	14	.684	.795	.212
DYSLEXIC	7	.694	.444	.168
MATH	14	.366	.765	.204



Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
MUSIC vs. ART	-.192	.634	.125	.613
MUSIC vs. DYSLEXIC	-.203	.755	.098	.543
MUSIC vs. MATH	.125	.634	.053	.398
ART vs. DYSLEXIC	-.01	.709	2.904E-4	.03
ART vs. MATH	.317	.579	.409	1.107

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
DYSLEXIC vs. MATH	.328	.709	.291	.934

TABLE FIFTY -SIX: CLQ SUB-GROUP SCORES AND POST HOC COMPARISONS

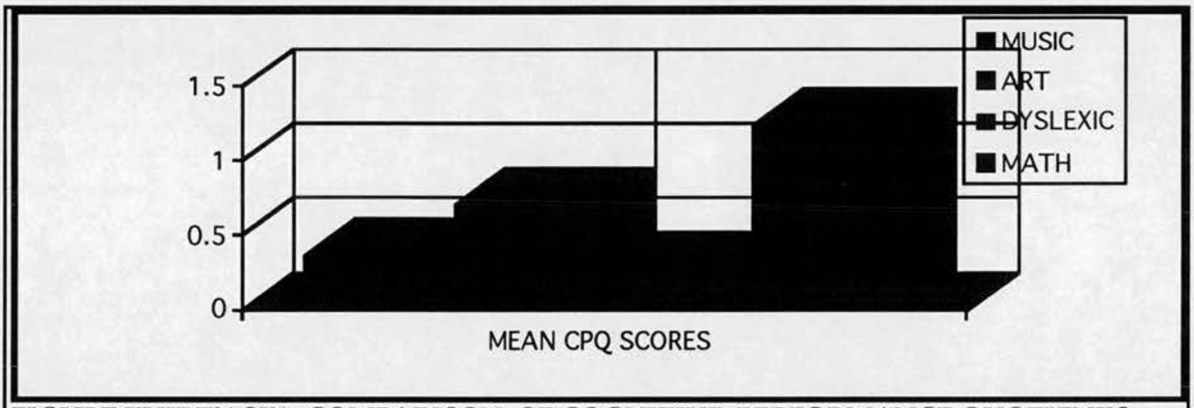


FIGURE THIRTY-SIX: COMPARISON OF COGNITIVE PERFORMANCE QUOTIENTS FOR THE FOUR SUB-GROUPS.;

Figure Thirty-six is a closer look at the final set of scores shown in **Figure Thirty-five**; the CPQ is the mean score for all the CLB sub-tests. In reducing order, the sub-group scores are Math, Art, Music, and Dyslexic.

CPQ
Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	3	6.436	2.145	8.443
Within groups	41	10.417	.254	p = .0002
Total	44	16.853		

TABLE FIFTY-SEVEN: ANOVA ON COGNITIVE PERFORMANCE QUOTIENT-COMPARISON OF SUB-GROUP SCORES

The ANOVA was significant (F-test=8.443, df=3/44, p<.0005) **[TABLE FIFTY-SEVEN]**, giving three significant pairwise comparisons:

1) musicians versus mathematicians (mean difference=-.874, p<.05)

2) artists versus mathematicians (mean difference=-.529, p<.05)

3) dyslexics versus mathematicians (mean difference=-.967, p<.05)

as shown in **Table Fifty-eight:**

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
MUSIC	10	.356	.741	.234
ART	14	.7	.436	.117
DYSLEXIC	7	.262	.413	.156
MATH	14	1.23	.39	.104

TABLE FIFTY-EIGHT: DESCRIPTIVE STATISTICS FOR COGNITIVE PERFORMANCE QUOTIENTS FOR THE FOUR SUB-GROUPS

While the standard deviations shown here [**TABLE FIFTY-EIGHT**] are still somewhat unsatisfactory, the average mean of .637 is accompanied by an average standard deviation of .495; because of this it may be argued that the overall score for all eight sub-tests which the CPQ represents may give a more trustworthy set of statistics than the individual sub-tests or component values alone.

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
MUSIC vs. ART	-.345	.422	.909	1.651
MUSIC vs. DYSLEXIC	.094	.502	.047	.376
MUSIC vs. MATH	-.874	.422*	5.845*	4.187
ART vs. DYSLEXIC	.438	.471	1.175	1.877
ART vs. MATH	-.529	.385*	2.573	2.779

* Significant at 95%

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
DYSLEXIC vs. MATH	-.967	.471 *	5.73*	4.146

* Significant at 95%

TABLE FIFTY-NINE: CPQ POST HOC COMPARISONS BETWEEN SUB-GROUPS AND SIGNIFICANCES

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
HAND SCORE				
MUSIC	10	16.3	1.703	.539
ART	13	14.385	4.011	1.113
DYSLEXIC	10	16.6	1.838	.581
MATH	14	14.5	3.798	1.015

TABLE SIXTY: HANDEDNESS SCORES FOR THE FOUR SUB-GROUPS

The handedness scores of the four sub-groups were compared [**TABLE SIXTY**], but there were no significant differences. Nevertheless, it is of some interest to note that the groups become more right-handed in a very similar fashion to the way the CPQ scores reduce: the low CPQ scorers, the Dyslexics, are also the most right-handed, while the high CPQ scoring group, the mathematicians, are much more left-handed, exceeded only fractionally by the Art group. This is a relationship suggested by evidence gathered together in the Literature Review, some of which suggests that mathematicians may be more likely to be left-handed; however, substantial evidence exists to support the view that dyslexics are more likely to be left-handed, directly contradicted by the present findings. Further research is required to investigate this anomaly, perhaps finding support for a non-linear relationship between these two variables.

Clearly, it seems the order of CPQ scoring has the mathematicians first, the artists next, followed by the musicians and then the dyslexics. It would appear that the musicians most closely resemble the dyslexics in their scoring. Nevertheless, it was decided to attempt to settle this question by conducting a Factor Analysis of these scores, to use all the sub-tests and their variations in order to find out which group resembled which.

FACTOR ANALYSIS ON GROUP MEANS

A Principal Component Analysis was carried out on the group means for the eight sub-tests (it would be improper to use the already-manipulated scores, such as the CLQ), using the Method Default of the Statview program; Transformation was Orthotran/Varimax, and the number of Factors extracted was 2.

	MUSIC	ART	DYSLEXIC	MATH
MUSIC	1			
ART	.527	1		
DYSLEXIC	.022	.623	1	
MATH	.663	.937	.367	1

TABLE SIXTY-ONE: CORRELATION MATRIX ON SUB-GROUPS

From this [TABLE SIXTY-ONE]it appears that the strongest correlation is between the artists and the mathematicians. The matrix sampling adequacy was .476 (Bartlett Test of Sphericity: df=9, Chi-Square=34.560, p<.0002).

	FACTOR ONE	FACTOR TWO
MUSIC	.693	-.625
ART	.971	.138
DYSLEXIC	.582	.766
MATH	.950	-.155

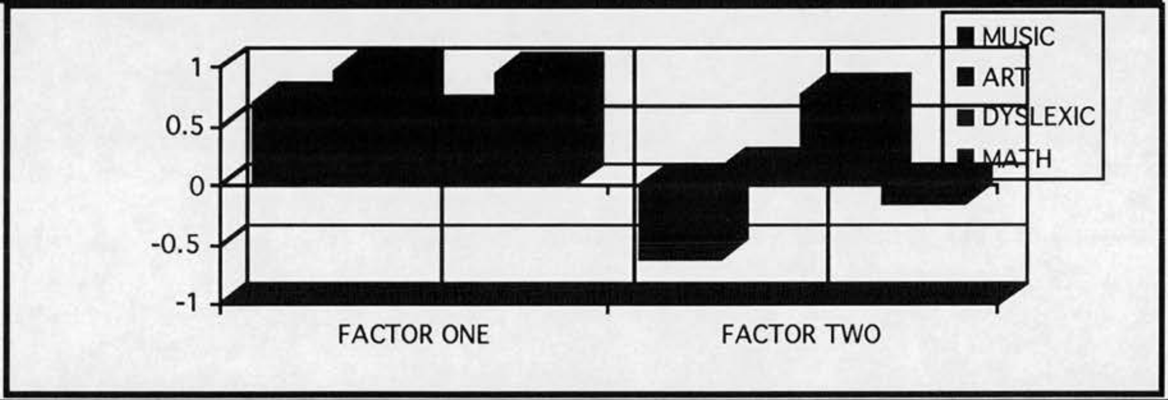
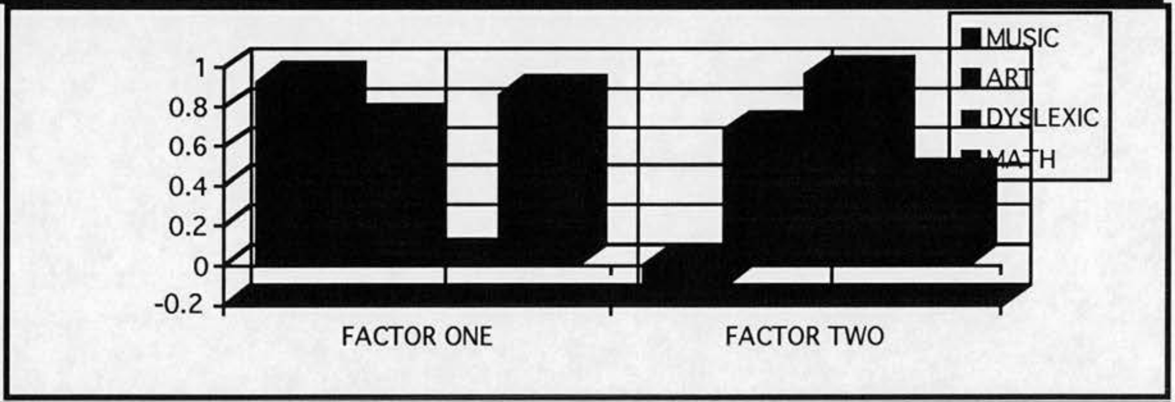


TABLE /GRAPH SIXTY-TWO: UNROTATED FACTOR MATRIX

It may be seen [TABLE SIXTY-TWO] that the artists and mathematicians load heavily on Factor One, while the dyslexics load on Factor Two. The Communality Summary was satisfactory, indicating that the same types of things were being measured.

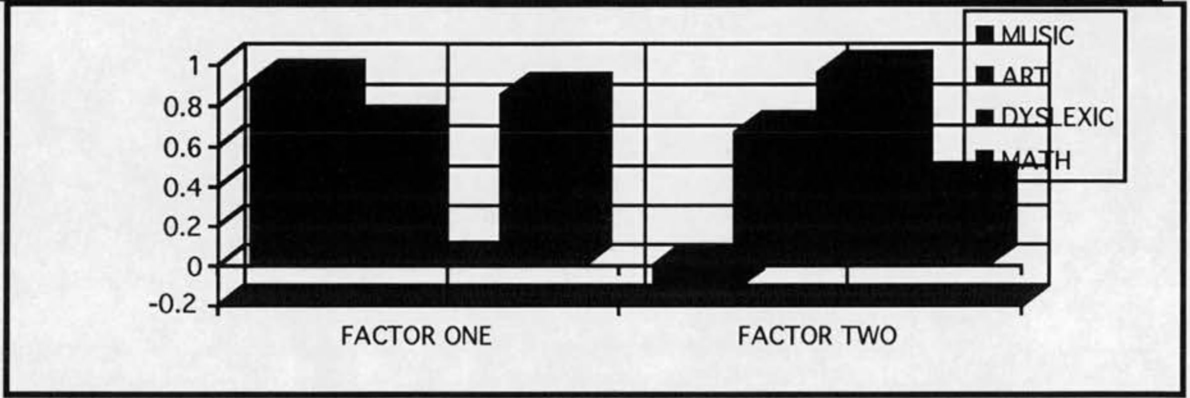
	FACTOR ONE	FACTOR TWO
MUSIC	.927	-.104
ART	.709	.678
DYSLEXIC	.027	.962
MATH	.863	.428



TABLE/GRAPH SIXTY-THREE ORTHOGONAL TRANSFORMATION SOLUTION-VARIMAX

Here [TABLE SIXTY-THREE], the rotation of the axes has assumed that there is no relationship between the groups; the fruits of this is that the loadings have changed, so that now the artists have begun to shift to Factor Two, together with the dyslexics.

	FACTOR ONE	FACTOR TWO
MUSIC	.929	-.116
ART	.700	.670
DYSLEXIC	.014	.961
MATH	.857	.417



TABLE/GRAPH SIXTY-FOUR: OBLIQUE SOLUTION PRIMARY PATTERN MATRIX ORTHOTRAN/VARIMAX

Now [**TABLE SIXTY-FOUR**], with the assumption behind the rotation of the axes that there may be association between groups, it may be seen that the artists are poised between both Factors with almost equal loadings, while the musicians and the mathematicians have gravitated into Factor One together. Primary intercorrelation between Factors One and Two equal .026, a small amount. Variable complexity is some way from being simple solution (1.372=Orthogonal, 1.369=Oblique; simple solution=1). Factor One contributed over 57% of the variance, while Factor Two contributed approximately 43%.

	FACTOR ONE	FACTOR TWO
MUSIC	.573	-.354
ART	.213	.320
DYSLEXIC	-.270	.741
MATH	.377	.080

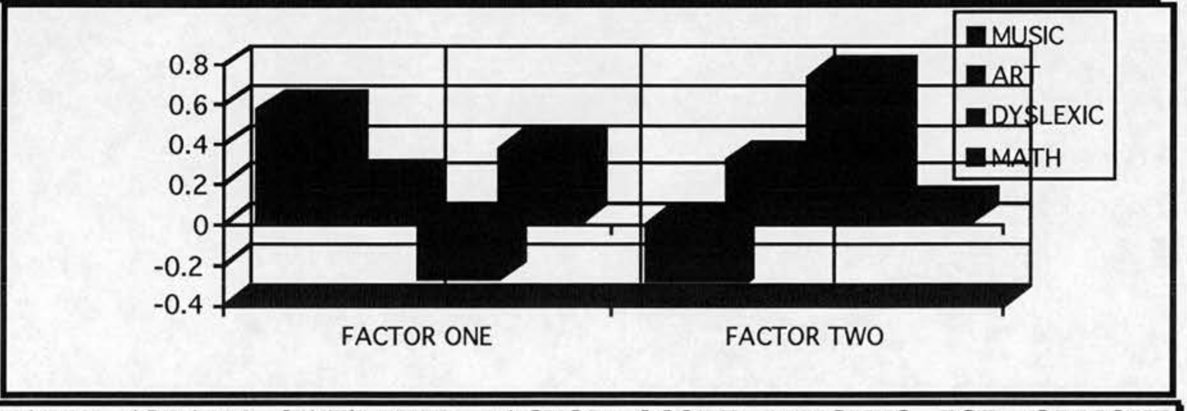
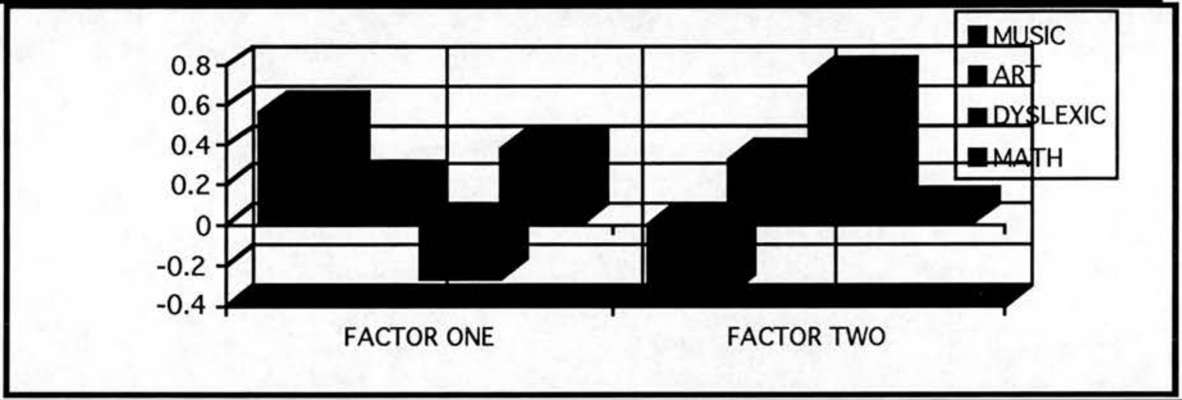


TABLE /GRAPH SIXTY-FIVE: FACTOR SCORE WEIGHTS FOR OBLIQUE TRANSFORMATION SOLUTION

With this final Oblique transformation solution [**TABLE SIXTY-FIVE**], it may be seen that musicians and mathematicians still load heavily on Factor One together, while the artists have almost completed their movement to join the dyslexics on Factor Two. The musicians have quite strong negative loadings on Factor Two, while the dyslexics have negative loadings on Factor One, increasing the distinctiveness of the two Factors.

	FACTOR ONE	FACTOR TWO
MUSIC	.568	-.346
ART	.217	.323
DYSLEXIC	-.260	.738
MATH	.378	.084



TABLE/GRAPH SIXTY-SIX: FACTOR SCORE WEIGHTS FOR ORTHOGONAL TRANSFORMATION SOLUTION-VARIMAX

The final table [**TABLE SIXTY-SIX**] quite closely resembles the previous one, so it may be assumed that such agreement between the Oblique and Orthogonal solutions means that a stable solution has been found. The initial conclusion from simply looking at the scores of the groups, that the musicians most closely resembled the dyslexics, may be true for simple, linear scoring, but when the more complex patterns of scoring on the sub-tests are considered, it is reasonably clear that the musicians most resemble the mathematicians; this, of course, is almost a routine relationship, observed time and again not only in the research literature but also in everyday thought (Music is "frozen mathematics", etc.). It is, nevertheless, satisfactory to find it by purely statistical means, as a confirmation that the test results and the statistics derived from them actually represent real-life relationships. The association between the artists and the dyslexics is less strong, although conclusive enough. It appears that the pattern of scoring on these tests by the artists revealed a similarity with the pattern of scoring of the dyslexics, something not noticed in earlier work, although speculated about by Geschwind and Galaburda (1985, 1987), and confirming the early, intuitive impulse to group them together for the purposes of the analysis.

REACTION TIME TESTS 1990-1991/EYE COLOUR AND SEX

MCCARTHY AND DONCHIN RESULTS:

To eliminate possible error variations in the individual conditions, the McCarthy and Donchin test conditions (**HASH-SAME/HASH-OPPOSITE; ABC SAME/ABC OPPOSITE**) were averaged to give "M & D Means", while the Sternberg results were condensed for the same reason into "SRT-NO" and "SRT-YES" means. These data were from undergraduate laboratory practical classes over 1990 and 1991.

DESCRIPTIVE STATISTICS:

Four Bar Charts of interest will be shown:

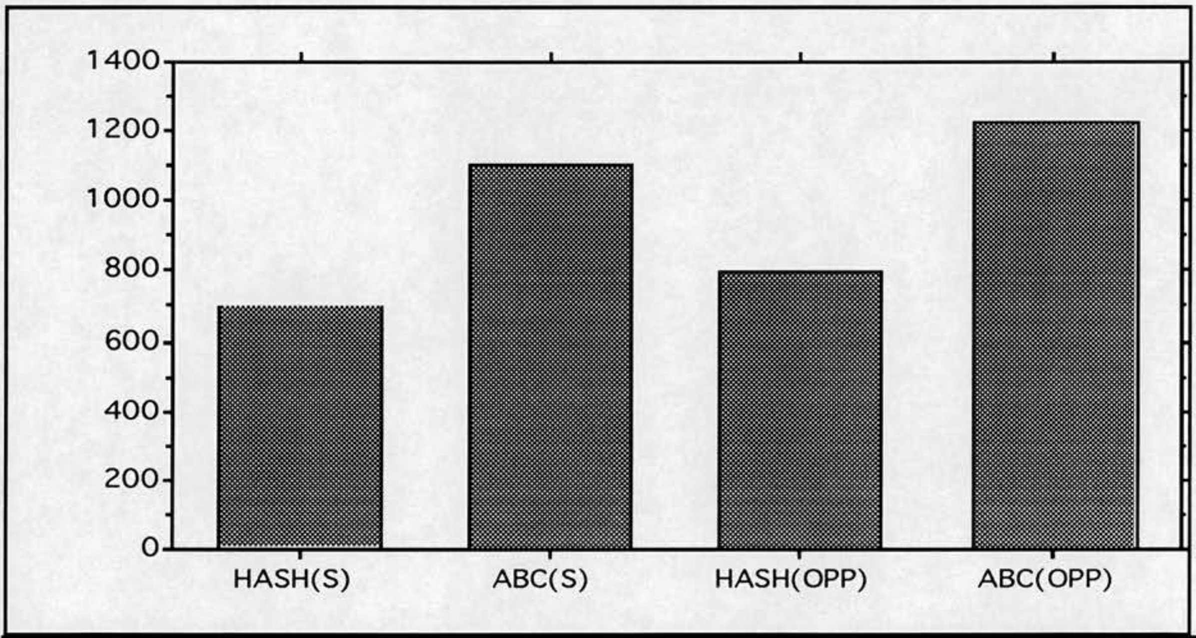


FIGURE THIRTY-SEVEN: BAR CHART FOR MCCARTHY AND DONCHIN TEST CONDITIONS (ms.);

It will be seen [**FIGURE THIRTY-SEVEN**] that, for both the 'SAME' and 'OPPOSITE' levels, the more difficult condition was the ABC, and that when the command was 'OPPOSITE' the task was more difficult than in conditions when the command was 'SAME', producing slower reaction times as more cognitive complexity was introduced into the task.

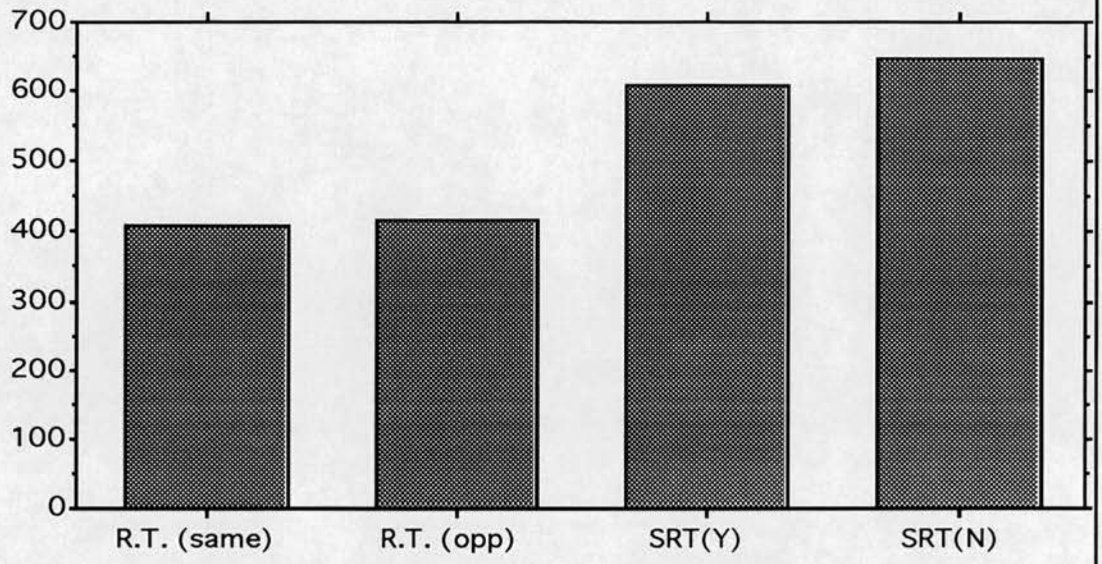


FIGURE THIRTY-EIGHT: BAR CHART FOR SAME AND OPPOSITE AND STERNBERG REACTION TIMES (ms.)

In this chart [**FIGURE THIRTY-EIGHT**]it is clear that for the means of the SAME and OPPOSITE tests there was little difference; however, for the Sternberg tests the one requiring a "NO" response was perhaps on average .500ms slower. It has been a reasonably robust finding over years of RT research of this sort that subjects find it more difficult to say "NO" in a choice situation and are therefore slower in doing so. More detailed analysis was required to uncover the statistical relationships.

INFERENTIAL STATISTICS

There were no significant differences between light- and dark-eyed individuals when all scores for 1990 to 1991 were analysed; however, there was found to be a difference in reaction time in favour of the dark-eyed of 9.95ms across both Sternberg conditions, and another of 22.19ms in the M & D means, going the same way. The dark-eyed had faster reaction times. When sex and eye colour were used as factors in a 2-Factor ANOVA, it was found that the M & D means gave no significant main effects or interactions, but showed in the Incidence tables that there was a distinct range of speeds according to both sex and eye colour. Significant main effects were found for sex in the *Same and ABC-Same measures, however [**TABLE SIXTY-SEVEN**]:

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Eye Colour (A)	1	458.643	458.643	.013	.911
Sex (B)	1	239056.191	239056.191	6.567	.0126
AB	1	1816.46	1816.46	.05	.8239
Error	69	2511832.393	36403.368		

TABLE SIXTY-SEVEN : TWO-FACTOR (EYE COLOUR AND SEX) ON *SAME RT MEASURE

It seems that on the measures involving more of a motor speed element, the less cognitively complex ones, the males were significantly better than the females (Males=632.178, Females=747.356). There were no significant interactions.

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Eye Colour (A)	1	3888.762	3888.762	.02	.8882
Sex (B)	1	936501.252	936501.252	4.797	.0319
AB	1	67510.207	67510.207	.346	.5584
Error	69	13469351.61	195207.994		

TABLE SIXTY-EIGHT : TWO-FACTOR ANOVA (EYE COLOUR AND SEX) ON ABC-SAME RT MEASURE

Again, the ABC-Same measure produced a significant sex difference (Male=981.925, Female=1205.512) [**TABLE SIXTY-EIGHT**]. Once more there are no significant interactions.

eye colour	sex	RT.. (ms)	N
Dark	male	848.867	15
Light	male	952.294	17
Light	female	998.958	26
Dark	female	1074.837	15

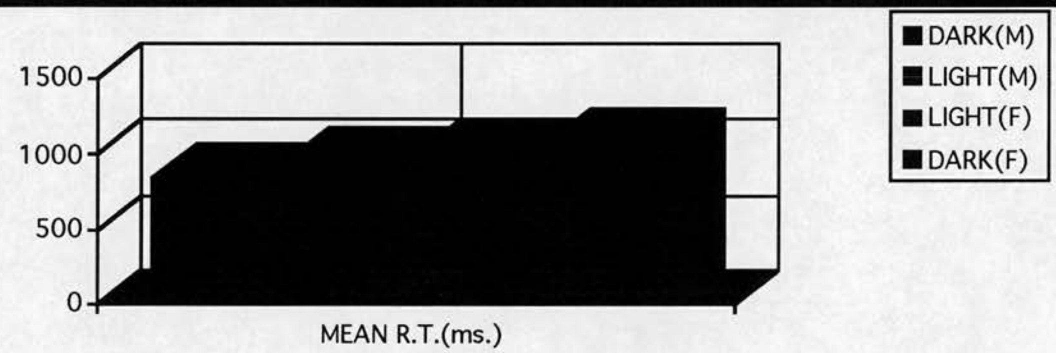


TABLE /GRAPH SIXTY-NINE: MCCARTHY AND DONCHIN MEANS

It was predicted that the dark eyed would be faster than the light eyed. The unusually slow dark-eyed female group [**TABLE SIXTY-NINE**] was removed from the data set, and an unpaired one-tailed t-test was carried out between the remaining light-eyed and now single-sex dark-eyed groups [**TABLE SEVENTY**]:

DF	t-value	prob.	eye col.	N	mean	Std. dev.	Std. err.
56	1.733	p<.05	light	43	980.509	277.150	42.265
			dark	15	848.867	161.903	41.803

TABLE SEVENTY: M & D MEANS/EYE COLOUR

If the same means (restoring the females previously removed) are examined looking only at the dark-eyed, the following result is obtained [**TABLE SEVENTY-ONE**]:

DF	t-value	prob.	sex	N	mean	Std. dev.	Std. err.
46	-2.164	p<.02	male	24	851.850	149.070	30.429
			female	24	1054.280	433.394	88.466

TABLE SEVENTY-ONE: M & D MEANS/DARK-EYED MALES AND FEMALES

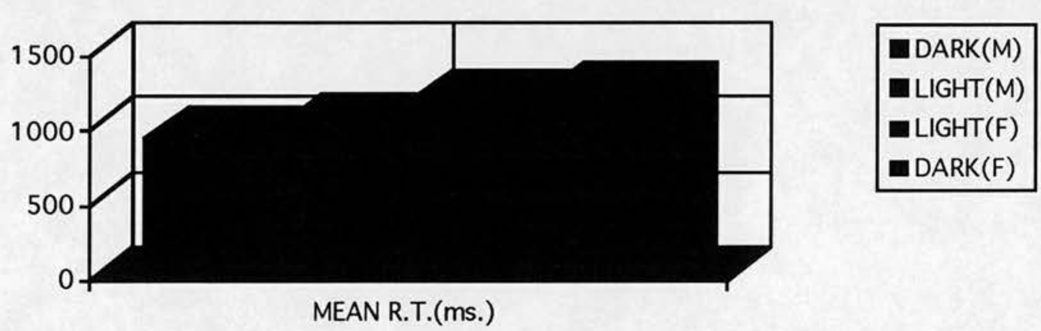
A difference of 202.437ms is seen in **Table Seventy-one** between the males and females who are dark-eyed; however, there is no significant difference between the light-eyed males and females, although in those there is a mean difference once more, in favour of the males, of 46.664ms. Similarly, there is no significant difference on the M & D means between light- and dark-eyed females, nor between light- and dark-eyed males, although the difference between the latter groups was 108.065ms, the dark-eyed being faster once more.

DF	t-value	prob.	sex	N	mean	Std. dev.	Std. err.
65	-1.736	p<.05	male	41	893.498	244.044	38.113
			female	26	998.958	239.410	46.952

TABLE SEVENTY-TWO: M & D MEANS/MALES AND FEMALES (DARK-EYED FEMALES REMOVED)

A significant sex difference is found, the males faster by an average of 105.460ms, even with the slow dark-eyed females removed [**TABLE SEVENTY-TWO**].

eye colour	sex	RT.. (ms)	N
Dark	male	940.827	15
Light	male	1018.188	17
Light	female	1188.165	26
Dark	female	1235.580	15



TABLE/GRAPH SEVENTY-THREE: M & D MEANS/MALES AND FEMALES (DARK-EYED FEMALES REMOVED)

There was almost a significant difference between the dark-eyed males and the dark-eyed females (p=.0581), the mean difference being 294.753ms. If the dark-eyed alone are analysed, looking at the times from the combined "same" M & D conditions, a one-tailed unpaired t-test gives the following result [**TABLE SEVENTY-FOUR**]:

DF	t-value	prob.	sex	N	mean	Std. dev.	Std. err.
38	-1.758	p<.05	male	20	310.900	190.166	42.522
			female	20	481.500	390.043	87.216

TABLE SEVENTY-FOUR: SEX DIFFERENCES/M & D "SAME" CONDITIONS COMBINED (DARK-EYED ONLY)

Once more the males are faster (170.600ms), in the easier condition. Although the harder "opposite" conditions failed to provide a significant difference (p=.0965) the mean difference between males and females in the dark-eyed group was larger, at 206.00ms (males=337.150, females=543.150). In the light-eyed group, the only significant difference was found in the HASH-SAME condition [**TABLE SEVENTY-FIVE**]:

DF	t-value	prob.	sex	N	mean	Std. dev.	Std. err.
41	-2.502	p<.01	male	17	634.565	131.805	31.967
			female	26	741.731	140.755	27.604

TABLE SEVENTY-FIVE: SEX/HASH-"SAME" CONDITION (LIGHT-EYED ONLY)

Yet again the males were on average faster (mean difference of 107.166ms).

1991-1992 REACTION TIME DATA/EYE COLOUR

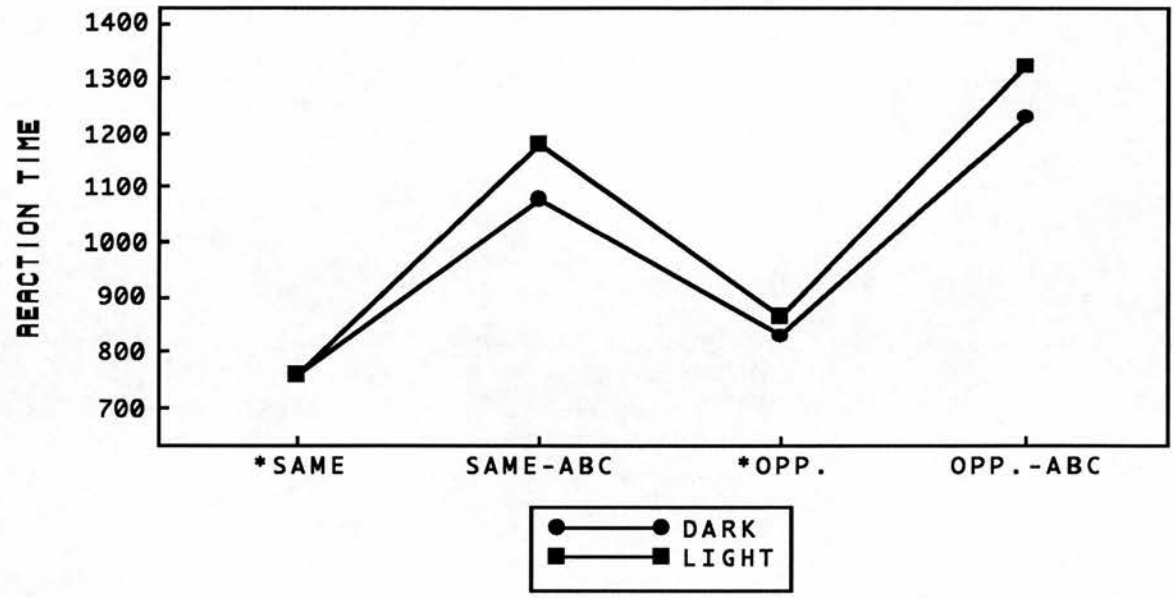


FIGURE THIRTY-NINE: COMPARISON BETWEEN '91/'92 DARK AND LIGHT EYED GROUPS ON THE FOUR MCARTHY AND DONCHIN RT. MEASURES (ms.);

The same tests were carried out on undergraduates the following academic year (1991-1992). As may be seen [**FIGURE THIRTY-NINE**], there is a consistent difference between the eye colour groups, the dark eyed group having the faster reaction times on these tests.

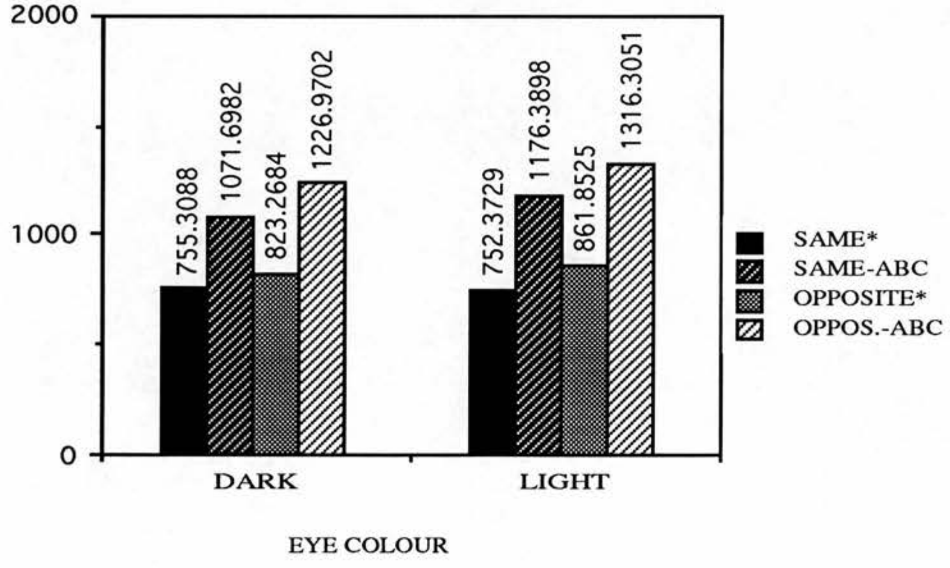


FIGURE FORTY: BAR GRAPH COMPARISONS OF THE FOUR RT. MEASURES (WITH VALUES) FOR BOTH EYE COLOUR GROUPS

In all but the first (***Same**) measure, the light eyed are slower [**FIGURE FORTY**].

DF:	Unpaired t Value:	Prob. (1-tail):
114	-1.742	.042

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
DARK	57	1071.698	285.4	37.802
LIGHT	59	1176.39	356.455	46.406

TABLE SEVENTY-SIX: EYE COLOUR T-TEST FOR SAME-ABC RT. MEASURE

In this second sample of 116 undergraduates there was a significant difference between eye colour groups for the Same-ABC reaction time measure [**TABLE SEVENTY-SIX**]; once more, as in the previous year's sample, the dark eyed group were faster. This time, however, no further manipulation of the data set was required-the result was more clear-cut from this second sample.

DF:	Unpaired t Value:	Prob. (1-tail):
114	-1.673	.0485

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
DARK	57	1226.97	274.905	36.412
LIGHT	59	1316.305	299.24	38.958

TABLE SEVENTY-SEVEN: EYE COLOUR T-TEST FOR ABC-OPPOSITE RT. MEASURE

Another significant difference was found between the eye colour groups for the ABC-Opposite reaction time measure [**TABLE SEVENTY-SEVEN**]; the ABC condition may well take more cognitive effort than the * condition, demonstrating perhaps the greater difficulty of picking out the stimulus from letters. Context independence may be measured by this test, to some extent.

STERNBERG TEST RESULTS 1990/1991

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Eye Colour (A)	1	8583.21	8583.21	.316	.5764
Sex (B)	1	110512.891	110512.891	4.064	.0485
AB	1	29787.045	29787.045	1.095	.2997
Error	57	1549856.816	27190.47		

TABLE SEVENTY-EIGHT: TWO FACTOR ANOVA ON (EYE COLOUR AND SEX) FOR THE STERNBERG RT. MEASURE

Turning to the Sternberg tests for 1990-1991, a similar pattern in the results may be detected [**TABLE SEVENTY-EIGHT**]. There was a significant main effect for sex on a two-factor ANOVA (F-test=4.064, df=1/57, p<.05). The Sternberg "NO" condition did not provide a significant difference on either ANOVA or t-test; the difference in reaction time, going the same way as before, was 90.834ms. **Table Seventy-nine** shows the "YES" condition means:

eye colour	sex	RT.. (ms)	N
Dark	male	524.592	13
Light	male	593.871	14
Light	female	635.622	21
Dark	female	656.503	13

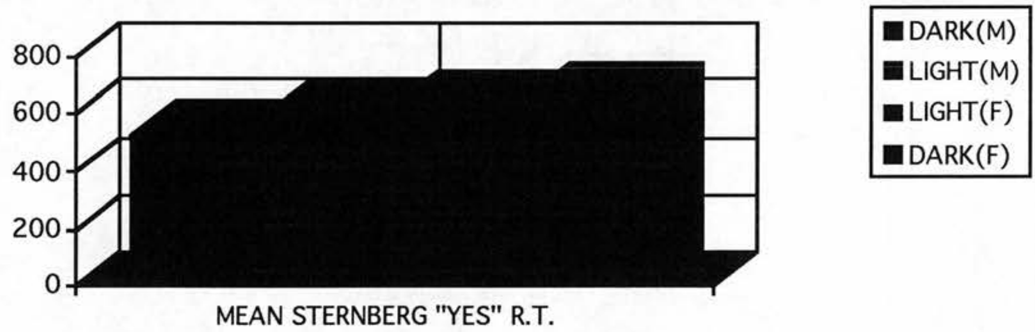


TABLE /GRAPH SEVENTY-NINE: STERNBERG "YES" CONDITION

If, in the Sternberg "YES" condition, the slow dark-eyed female group is removed, a significant difference arises between eye colours [**TABLE EIGHTY**]:

DF	t-value	prob.	eye col.	N	mean	Std. dev.	Std. err.
46	1.992	p<.05	light	35	618.921	153.397	25.929
			dark	13	524.592	121.808	33.784

TABLE EIGHTY: EYE COLOUR/STERNBERG "YES" CONDITION (DARK-EYED FEMALES REMOVED)-T-TEST

There was a mean difference in reaction time of 94.329ms between the dark-eyed males and the light-eyed of both sexes. Sex showed a significant difference, as would by now be expected [**TABLE EIGHTY-ONE**]:

DF	t-value	prob.	sex	N	mean	Std. dev.	Std. err
46	-1.754	p<.05	male	27	560.514	151.504	29.157
			female	21	635.622	141.246	30.822

TABLE EIGHTY-ONE: SEX/STERNBERG "YES" CONDITION (DARK-EYED FEMALES REMOVED)-T-TEST

The reaction time mean difference was 75.108ms. The Sternberg "NO" condition was almost significant for sex (p=.0626), with a mean difference in reaction time of 69.934ms. Within the dark-eyed only, a significant sex difference emerged for this same "YES" condition [**TABLE EIGHTY-TWO**]:

DF	t-value	prob.	sex	N	mean	Std. dev.	Std. err.
24	-1.884	p<.05	male	13	524.592	121.808	33.784
			female	13	656.503	221.061	61.311

TABLE EIGHTY-TWO : SEX/STERNBERG "YES" CONDITION (DARK-EYED ONLY)-T-TEST

The mean reaction time difference between these groups is 131.911ms. In the Sternberg "NO" condition there was no significant difference between the sexes, the mean reaction time difference being 90.834ms. If the same thing is done for the light-eyed group no significant difference is found between the sexes, the mean difference in reaction time (in favour of the males) being 41.751ms for the "YES" condition and 49.793ms for the "NO" condition. There were no further significant differences for eye colour within the male or female groups.

SUMMARY

Somatic Variables

The mean CPQ for the whole sample was .744, a good score, more than half a standard deviation above the norms established by Gordon. If that were to be roughly translated to an IQ score, superimposing the z-scores over an normal IQ distribution curve, such a mean would represent an average IQ of 112. As the psychometric literature frequently mentions approximately 115 as being the basic minimum IQ score for University entrance and degree capability, then this sample satisfies that criterion.

Unhappily for the "Left Hand Pathology" of Geschwind and Galaburda, hand played a muted role in the findings: a z-score difference between the hands of just .003 in favour of the left-handers made little significant difference overall. 85.926% of the sample were right-handed (14.074% left-handed). The only interesting-and significant (p<.02)-hand difference was in the Form Completion sub-test [**TABLE EIGHTY-THREE**]:

HAND - FORM COMPLETION

DF:	Unpaired t Value:	Prob. (1-tail):
120	-2.288	.012

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
RIGHT	105	.667	.975	.095
LEFT	17	1.232	.716	.174

TABLE EIGHTY-THREE: T-TEST FOR HAND DIFFERENCE ON THE FORM COMPLETION SUB-TEST

Left-handers (1.232) were significantly better than right-handers (.667) at this test of visual gestalt recognition.

While the dichotomy 'Left/Right' produced little from the CLB scores, the more sensitive Hand Score brought out more: Asthma and Musical ability proved good discriminators, producing marginally significant differences by t-test. Left-handers, or those inclining toward left-handedness, showed themselves here to be more likely to be asthmatic and without musical ability. Mathematical ability was the only variable to support the hypothesis dealing with hand, that left-handers would prove mathematically able and therefore notionally superior to right-handers who are less likely to have such ability. That they would prove superior for right hemisphere/Appositional tasks, was, however, not supported; it may be argued, nonetheless, that mathematical ability requires such right hemisphere, Appositional functions

The results suggest that not only was there a significant association between self-reported clumsiness as a child and being identified as one of the low scoring 30 on the CLB, but also clumsiness identified someone likely to score relatively less well on the Appositional sub-tests. This is not to say that these students suffered clinical dyspraxia-one of the main points of this thesis is that disorders such as dyspraxia are simply the extreme examples of tendencies present to a greater or lesser degree in most people. Interestingly, it was in just those sub-tests which could be predicted to have a bearing on matters to do with spatial orientation and awareness, body positioning and accuracy of body-space awareness, that the students scored less well; the results would have been counter-intuitive if they had shown Propositional low scoring. The possibility that these results were the result of statistical artefacts derived from multiple comparisons within one sample is therefore less likely.

Of course, as the scores were lower in three of the eight sub-tests, the CPQ was correspondingly lower, accounting for clumsy students occupying so much of the lower 30 scorers section. The clumsy scored a mean of .616 on all 8 sub-tests (CPQ), while those not afflicted scored .948 (difference=.332), which is equivalent to a 7 point IQ difference. There were 28.788% who admitted being clumsy in the whole sample. The hypothesis dealing with clumsiness was largely supported, although sociability (or the lack of it) did not emerge as a significant factor (35.385% of the sample said "yes", they did not like people-this may be a function of the high content of artists, architects, and musicians: if the section dealing with Arts students is consulted, it will be seen that this would be expected of them).

To gain some idea of the actual z-score difference between the means for those in the low 30 and those in the high 30, it amounts to 1.399, with an IQ conversion of 22 points. For an undergraduate population in which variance has been reduced by years of educational test winnowing, this is a remarkably wide difference in presumed intelligence. However, it must be remembered that from this population must come the higher degree candidates and presumptive professors of the future, who, according to most psychometricians, ought to have IQs of at least 130. In addition, a proportion were first year students, some of whom may have entered University by barely passing the required exams. As IQ and educational success correlate highly, these could be of lower than expected intelligence; it is from these that most University drop-outs derive. It follows that students from later years would have shown an overall even more reduced variance.

79% of the low 30 was light-eyed (as compared with 59.504% of the whole sample), a result which may reflect the speeded element in the CLB: the reaction time data, especially that from 1991-1992, shows that the light-eyed males and females would always be slower at such tasks than the dark-eyed. No large effect for laterality was found, as the sub-tests contributing to this difference were spread equally over both Appositional and Propositional sides; nevertheless, both the Propositional ($p<.02$) and Appositional ($p<.05$) sub-tests registered a significant difference; perhaps the speed difference between eye colours would always be a handicap for the light-eyed for a speeded paper and pencil test.

Within only the top and bottom 30 scores similar significant overall differences appeared between the two eye colour groups, with the dark-eyed significantly more left hemispheric in their dominance. Hair colour mirrored the eye colour results. Eye colour and familial allergies were marginally associated, 79% of the light-eyed having them;

nevertheless, when eye colour and personal allergy were compared, the highest scores were obtained by those with both dark eyes and allergy. Allergy gave a main effect on the ANOVA, so it is a strong influence (50% of the sample claimed allergies of various sorts), but one which may act more strongly still in alliance with another influence, such as dark eye colour. If the mean scores for dark-haired individuals and light-haired individuals are studied, it may be seen that the difference between them (.197) in favour of the dark-haired represents a difference of approximately 3 points in IQ, if the z-scores are interpreted on a normal IQ distribution. A similar difference in the same direction exists for eye colour (z-score difference=.276). Allergy provides another 3/4 point difference, in favour of having allergies (z-score difference=.316).

Returning to the lack of support for the present writer's hypothesis that both dark eyes **and** allergies are found most often in high cognitive ability individuals, it must be remembered that this sample is already selected for high ability (it is a University student population) it follows that the high ability light-eyed in the sample may be more likely than their equivalents in normal society to suffer from allergies. It must be emphasised that the cognitive ability differences found here between light- and dark-eyed individuals are relative only: both groups score well in relation to Gordon's norms, but the dark-eyed usually score more highly than the light-eyed; in a sample from the normal population much greater differences would be found as a simple function of an increase in the sample variance, with many more scoring well below the norms.

77.78% of the sample had both allergies and asthma (in the whole sample 13.235% reported having asthma). The difference between having asthma and not having it made little z-score difference, although familial asthma was more influential: the mean difference for that variable was .275, giving another notional 4 IQ points difference, in favour of those who did not have asthmatics in the family.

71% of those born in those dangerous months of February, March, April, and May were to be found in the low 30 (38.462% were LWB in the whole sample). When the sub-tests contributing most to this difference were examined, verbal fluency and spatial rotation were found to be the chief ones. A 4 point IQ difference exists between those born in late winter and those born in some other month (z-score difference=.287), in favour of those not having LWB. The LWB hypothesis was supported ($p<.02$).

If the most influential of the above variables are studied, no significant interaction was found between birth in the late winter, eye colour, and clumsiness, although the lowest score (.336) was for those with clumsiness, light eye colour, and born in those months, and the highest was predominantly for those without those factors (1.164). The dark-eyed, protected by their pigmentation, perhaps, were less affected by Late Winter Birth than the apparently more vulnerable light-eyed, two dark-eyed, clumsy LWB individuals actually scored most highly of all (1.372) . As the lowest scoring group were those who shared three of the variables designated as disadvantageous, the General Hypothesis was upheld in this case.

These LWB individuals-thought to stand the greater risk of developing schizophrenia-do not score as highly on the CPQ as those born at other times. Although the effect was clear in both Appositional and Propositional scores, the sub-tests where it was most strongly felt were those testing memory for sequences of sounds ($p<.05$) or numbers ($p<.05$), and spatial rotation ($p<.01$), areas of competence usually associated with ability in mathematics and engineering. It therefore follows that being born early in the year may be a disadvantage, in some, for a career in such disciplines. All sub-test means showed the test superiority of those not born in this period.

Myopia was another somatic or mildly pathological characteristic which made a difference to CLB scoring: most had other myopics in the family, indicating a genetic influence; however, there was no support for the Benbow (1986) findings: 58.82% of myopics had allergies and 41.18% were without allergies, a non-significant difference. On the means there was only a .106 z-score difference between myopics and non-myopics, those without short-sight scoring more highly. This variable had little influence on CLB scores, unlike allergy. It marginally associated with sex, however, 61.11% of the females in the sample being myopic, and only 37.5% of the males (overall, 50% said they were myopic).

As there was only a .154 z-score difference in favour of the males, sex differences exerted little influence on the CLB scoring, although they should not be ignored.

Child illness, the self-report of a childhood and schooling often interrupted by bouts of fairly serious illness, was strongly influential: it was associated with allergies, asthma, and familial asthma; when the CLB scores were examined they showed that child illness was associated with non-significant lowered Propositional scoring. Can this be interpreted to mean that such frequent early illnesses had an adverse effect on the left hemisphere growth of these children, which has remained with them until adulthood? A pointer in this direction may be that the hand scores showed those who admitted childhood illness of this severity were, as well, more left-handed (13.273 to 15.171 for those who claimed to be relatively healthy as children).

Once more, the scores on the handedness measure for those with and without asthma should be recalled, which serve to reinforce the picture of the left-handed child as more subject to disorders of the immune system. Child illness produced a main effect ($p<.05$) in the ANOVA [**TABLE EIGHTY-FOUR**], as did Allergies ($p<.02$) and Eye colour ($p<.02$); there were no significant interactions:

Anova table for a 3-factor Analysis of Variance			COG. SCORE		
Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
CHILD ILL. (A)	1	1.285	1.285	5.169	.0277
ALLERGIES (B)	1	1.602	1.602	6.442	.0146
AB	1	.474	.474	1.904	.1743
EYE COLOUR (C)	1	1.768	1.768	7.109	.0105
AC	1	.088	.088	.355	.5544
BC	1	1.504E-6	1.504E-6	6.047E-6	.998
ABC	1	.005	.005	.022	.8827
Error	46	11.439	.249		

The ABC Incidence table COG. SCORE

	ALLERGIES:	YES		NO		Totals:
	EYE COLOUR:	LIGHT	DARK	LIGHT	DARK	
CHILD ILL	YES	7 .621	3 1.282	1 -.243	1 .482	12 .703
	NO	12 .906	6 1.377	15 .691	9 1.1	42 .938
Totals:		19 .801	9 1.346	16 .633	10 1.038	54 .886

TABLE EIGHTY-FOUR: THREE FACTOR ANOVA ON ALLERGIES, EYE COLOUR, AND CHILD ILLNESS FOR THE CPQ MEASURE

Child illness had associated (p<.02), however, with early walking (62.5% answered 'Yes' to both, 83.93% said 'No' to both), a counter-intuitive finding, which may lead to suspicions that not all precocity is healthy; however, given the association with allergy, it may be that for some the early illness reported was allergy-connected, allergies being an influence now known to be associated with higher scoring on the CLB (p<.05, 'Yes'=.976, 'No'=.660). The concatenation of factors dark eyes/allergic/healthy childhood scored more highly on the CLB than that of light eyes/no allergies/childhood illness. A z-score difference of .235 gives a possible IQ score difference of 3 points between those who had childhood illness and those who did not, in favour of the healthy (23.077% of the sample recalled having frequent childhood illness). The part of the childhood illness hypothesis dealing with test scores was weakly upheld.

With the curious, but possibly explicable exception of early walking (12.5% said that their parents had told them they walked unusually early), all the significant and influential somatic variables as detailed above demonstrate that ostensibly mild pathologies and ostensibly non-pathological constitutional variables may be associated with lower scoring on a cognitive test. In the case of allergy, a mild pathology, and supporting the findings of other researchers, something which appears disadvantageous may be evidence of an immune system operating too well, evidence of greater rather than lesser bodily health. Sufferers from AIDS know only too well what harm a poorly functioning immune system can do. The findings in this section in general support the General Hypothesis.

Psychological Variables
Mathematical ability was associated with scoring in the top 30 of the CPQ measures: 94% of the top 30 had math ability (compared with 61.765% in the whole sample). It associated with graphic art preference (60.784% overall preferred either to produce or to look at such art), the non-mathematical preferring painterly art works, with 91.7% of those who like graphic art liking black-and-white art work, too (compared with 42.308% of the whole sample-immediately it is recalled that this was in Erich Fromm's list of characteristics of the necrophile or psychopath!); geometrical doodling was preferred by what appear to have been much the same sort of people (80.5%, as compared with 73.016% of the whole). Indeed, 64.7% of the geometrical doodlers had math ability. The significant difference on the Appositional scores of the CLB for the geometric versus organic doodlers ($p<.05$, 1.191 Geometric, .815 Organic), with no difference on the Propositional scores, seems to indicate that those who use geometrical patterns in their doodles have greater facility for those cognitive tasks which have been identified as best processed in the right cerebral hemisphere. 62.903% of the sample had an Appositional cognitive superiority in scoring-what could be termed a 'cognitive style'. 75.68% of the geometrical doodlers were Appositional dominant, with 77.78% of the Appositional dominants being geometrical doodlers; however, the association did not reach significance, probably requiring a larger sample size.

Possession or not of mathematical ability significantly and decisively dichotomised the CLB scoring: z-score differences for the whole sample were in favour of the mathematically able by .662, which if converted to IQ scoring, indicates a difference of 10/11 points. There was a marginally larger differential on the Appositional scoring (.755) to the Propositional (.568), as measured from the t-test means. Association with graphic preference ($p<.01$-75.76% of the mathematical preferred graphic images) tells a story of a preference for abstracted, linear, hard-edged, reductionist images, without that emotional dimension, colour, further supporting the claim concerning the semi-psychopath/Asperger's Syndrome/'train-spotter' element conjectured to exist in some people drawn to the Sciences.
For those mathematically able individuals who could draw, there was no strong drive to keep doing so; it was a talent among others and not pre-eminent. If the z-scores for graphic preference and painterly preference are compared, the graphic preference significantly associated with higher scoring ($p<.05$), producing a difference of .374, an equivalent of an IQ score difference of 4 points in favour of the graphics people. This aside, the mathematical ability/test scoring hypothesis appears to have been upheld.
An omission in the significant scores was early perspective, assumed to be connected with artistic ability, but which did not manifest a connection: the z-score difference between having this and not having it is small, .182, in favour of those with early perspective (so many, 46.809%, claimed to have developed an early sense of perspective-this question applied only to those who said they had artistic ability-that doubt must be cast on both the quality of their memories and their humility: it does not seem likely that such a difficult skill, not usually developed until well into adolescence, if then, could have been mastered by so many. The probe questions which were asked to elicit this response to the interviewer's satisfaction heavily emphasised their early

methods of house drawing: if a drawing was mentioned which included two walls, an angled roof, and a fence or two which diminished with distance and did not sag flatly by the pathway, then that person was judged to have mastered perspective at 4 or 5 or 6 years). Judged solely on the CPQ finding, the early perspective hypothesis was weakly supported.

When mathematical ability, strong in itself as an influence on scoring, was paired with imaginative drawing ability, the effect was heightened. Imaginative drawing on its own associated with presence in the top 30 scorers, and, mostly on the basis of the differences found in the Propositional, verbal-sequential sub-tests, it significantly dichotomised the CLB scores, too (63.265% of those who had artistic ability claimed they drew imaginatively). Both had main effects in an ANOVA **[TABLE EIGHTY-FIVE]** but no interaction:

Anova table for a 2-factor Analysis of Variance **COG. SCORE**

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
MATH ABILITY (A)	1	3.59	3.59	14.987	.0005
IMAG. DRAW. (B)	1	2.477	2.477	10.34	.003
AB	1	.25	.25	1.043	.3149
Error	32	7.665	.24		

MATH AB.	IMAG. DRAW.:	YES	NO	Totals:
	YES	17 1.203	10 .767	27 1.042
	NO	6 .637	3 -.204	9 .357
	Totals:	23 1.056	13 .543	36 .871

TABLE EIGHTY-FIVE: TWO FACTOR ANOVA ON IMAGINATIVE DRAWING AND MATHEMATICAL ABILITY FOR CPQ SCORES

Mathematical ability was somewhat the stronger influence than imaginative drawing; those without either actually drop below Gordon's norms, exceptional in this University population. Nevertheless, those possessing both scored best on the CPQ cognitive score (1.203), while those without either scored lowest of all (-.204). If the difference between the z-scores for imaginative drawing is looked at, .513, this represents a gap of 10 points on an IQ scale, in favour of those able to draw "from their heads" rather than copy. It would seem a fairly trivial claim that the highly imaginative must function cognitively rather better than those hewing more closely to the concrete realities; nevertheless, the imaginative drawing hypothesis is quite strongly supported.

Daydreaming; this is the sort of "deep" daydreaming exemplified by the eater at the dinner-table who pauses with a fork-full of food nearly to the lips....and stays that way for seconds or even minutes, or the person who stands and stares out of a window without really seeing what is outside; both are so involved in their fantasies and thoughts that for what may seem to others an embarrassingly long time their inner life takes total precedence over their outer life. Only the snapping of fingers or a discreet prod will bring them "back" from the almost involuntary invisible journey they have taken. This variable produced strong effects as well: 83% of the low 30 scorers were daydreamers (compared with 56.923% overall), the most powerful effect being on the Appositional sub-tests ($p<.01$, 'Yes'=.883, 'No'=1.306 for the whole sample). The daydreaming hypothesis predicted that there would be an association between that characteristic and a right hemisphere or Appositional profile; there does seem to be a negative relationship: the low scores which contribute most to the daydreamers in the Low group appear to be the Appositional ones, although overall lowered Propositional scores contribute most to placing in that Low group. The Propositional z-score difference between those who do and those who do not daydream is .249; the Appositional scores produce a difference of .612. If these were considered to be equivalent to the Wechsler Performance scores, then a "Performance IQ" score difference would be even greater, between IQ 120 and IQ 112.

Art ability associated with being in the Arts culture, as expected, although only weakly ($p=.0707$): 79.49% of those judged to belong to a discipline which did not foreground or have as an essential component the use of mathematics claimed artistic ability; unexpectedly, 55.56% of the Science culture had art ability, too, indicating that they had more talents than math ability. However, the poor levels of Science students who said they had a **need** to draw indicated that art was not their main interest. The 51.28% of Arts students who said they had but the one talent (84.62% of Science students claiming many talents) made this point (compared with 35.821% monotalented in the whole sample), especially when compared with only 15.38% saying the same in the Sciences. Those who had only one talent substantially outnumbered those with more than one when saying they had a need to draw (77.7%). A curious finding (but not inexplicable-see review on the personality of the artist) was that 76.47% of those who said they had a strong need to draw were reluctant to associate with others. Most of those in the sample who said they had no mathematical ability being in the Arts culture group, it was no surprise to find that 70.97% of them had a need to draw (67.647% of the whole sample claimed to be artistically talented, while 51.064% claimed a need to draw-both sets of claims need to be treated with some scepticism, indicating an over-valuation of both their own talents and their dedication!).

The part of the hypothesis dealing with a predicted association between daydreaming and artistic ability was not supported

When art ability, math ability, and daydreaming were compared in an ANOVA (significant only for Math ability=$p<.005$), having art ability was shown to reduce CPQ scores, but by very little (.166). All those subjects with an artistic mother were Appositional in cognitive style (and 88% of those with a mathematical father; it seems that the children of an artistic mother and a mathematical father are almost certain to have an Appositional cognitive style!).
Having an artistic mother seemed to disincline the offspring to prefer abstract art; such a mother seemed to have a lowering effect on scoring: the z-score difference for those with against those without an artistic mother was .235, the equivalent of an IQ difference of 3 points. This may be because the art students more often had an artistic

mother; art students scored less well generally. Similarly, having a musical mother did not help scoring: a z-score difference of .274 is equal to approximately 4 IQ points, in favour of those without such a mother. As with the artistic mother, many of the effects derive from an association with the offspring following in their footsteps: 86.4% of those with a musical mother had musical ability, too. Overall, the prediction that the artistic would prefer realistic art work, either produced or viewed by them, was mildly supported through their artistic mothers; there did not seem to be an association between being artistic and having a right hemisphere or Appositional cognitive style: 68.25% of the Science students were Appositional.

Cross Relationships

Daydreaming and familial myopia, together with loss of reality, as one may expect from deleterious factors, are birds of dark feather flocking together. When looking at the Cognitive Laterality Quotient, on an ANOVA the significant interactions were between allergies, clumsiness, and early perspective [**TABLE EIGHTY-SIX**]:

Anova table for a 3-factor Analysis of Variance — COG. SCORE

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
ALLERGIES (A)	1	.051	.051	.281	.6001
CLUMSY (B)	1	.677	.677	3.736	.0634
AB	1	1.956	1.956	10.794	.0027
EARLY PERSP. (C)	1	.005	.005	.03	.8637
AC	1	2.582	2.582	14.252	.0008
BC	1	.285	.285	1.576	.2198
ABC	1	.677	.677	3.734	.0635
Error	28	5.073	.181		

The ABC Incidence table — COG. SCORE

	CLUMSY:	YES		NO		Totals:
	EARLY PERSP.:	YES	NO	YES	NO	
ALLERGIES	YES	3 .829	4 .04	5 1.603	7 1.045	19 .946
	NO	3 .506	1 1.664	7 .819	6 .89	17 .838
	Totals:	6 .667	5 .365	12 1.146	13 .973	36 .895

TABLE EIGHTY-SIX: THREE FACTOR ANOVA ON ALLERGIES, CLUMSINESS, AND EARLY PERSPECTIVE FOR CPQ SCORES.

There were no significant main effects; however, there were interactions for all three variables: one outlier in the cell for clumsy without allergy and without early perspective may well have contributed misleadingly to the interactions (1.664); if this is disregarded, the story told by the interactions seems to be that those individuals without clumsiness score more highly, adding allergy raises the scoring; however, claiming early perspective made a difference in scoring, increasing scoring, but only for those with allergies. For those with allergies and clumsiness, having early perspective increased scoring, while for those with clumsiness but no allergies having early perspective apparently decreased scoring. If the 'outlier' is disregarded, this anomaly may disappear, bringing scoring in line with that for the subjects without clumsiness. It seems there may be an association between allergy and right hemisphere precocity, if early perspective depends on highly developed right hemisphere spatial abilities. Some of the predictions of the Geschwind and Galaburda theory appear to be upheld by this association. Similarly, artistic ability has associated with it birth in the late winter **[TABLE EIGHTY-SEVEN]**:

Anova table for a 2-factor Analysis of Variance COG. SCORE

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
ART ABILITY (A)	1	1.535	1.535	4.253	.0443
LATE WINTER BIRTH (...	1	2.085	2.085	5.775	.0199
AB	1	1.146	1.146	3.175	.0807
Error	51	18.415	.361		

The AB Incidence table COG. SCORE

	LATE WINTER ...	YES	NO	Totals:
ART ABIL...	YES	15 .826	18 .941	33 .889
	NO	5 .113	17 .889	22 .713
Totals:		20 .648	35 .916	55 .819

TABLE EIGHTY-SEVEN: TWO FACTOR ANOVA ON ART ABILITY AND LWB FOR CPQ SCORES

There was not a significant interaction, but both variables showed significant main effects. The incidence table revealed that having artistic ability increased scoring, especially for those born in late winter. Those without artistic ability and born in late winter showed the lowest scoring (.113), while the highest scoring was for those with artistic ability who were not born in those four months (.941).

Need to draw is associated with asthma ($p<.05$), all of those with asthma having a need to draw. 20.51% of Arts students had asthma, with only 3.7% of the Science students suffering similarly; a similar relationship exists for those who claim art ability: 15.22% of the artistically able suffering from asthma and only 9.09% of those not so gifted having that disorder. The relationships are weak but suggestive; a larger sample may well produce a stronger link. Familial asthma is associated with having but the one area of talent ($p<.05$), 58.82% of those with asthma in the family being monotalented, while only 27.08% of those without familial asthma have that single area of talent; **[TABLE EIGHTY-EIGHT]**:

Anova table for a 2-factor Analysis of Variance COG. SCORE

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
F. AST. (A)	1	.567	.567	1.45	.2343
MONOTALENT (B)	1	1.584	1.584	4.052	.0495
AB	1	1.605	1.605	4.106	.0481
Error	50	19.55	.391		

The AB Incidence table COG. SCORE

MONOTALENT:		YES	NO	Totals:
F. AST.	YES	7 1.069	7 .23	14 .65
	NO	8 .898	32 .901	40 .901
Totals:		15 .978	39 .781	54 .835

TABLE EIGHTY-EIGHT: TWO FACTOR ANOVA ON FAMILIAL ASTHMA AND MONOTALENT FOR CPQ SCORES

Curiously, while those without familial asthma showed no difference in scoring between those with one talent only and those with more than one, those with such a familial disorder showed a very sharp difference (1.069 to .230). It remains that the lowest score was for the group without monotalent but with familial asthma (.230); it is possible that the interaction observable in the ANOVA table shows that the influence of familial asthma as a deleterious factor may be reversed in those who have cultivated their single ability.

Monotalent is associated with clumsiness, and myopia is associated with being an organic doodler. This network of short or long strings of disadvantageous factors, with some others, associates with all the lower cognitive test scores. Cause and effect cannot be assumed with correlational or associative measures; however, what may be said is that their presence together with lower test scoring is strongly suggestive of an underlying relationship.

Mathematical ability, on the other hand, draws to itself a congeries of advantageous factors: dark eye colour, a lack of familial asthma, and a healthy childhood; in an ANOVA there was a significant interaction, as well, with the power to draw imaginatively ($p<.05$), speaking somewhat of the need for imaging abilities in mathematics, something probably derived from their equal power in both cognitive styles (or could it be that, like a bodybuilder "pumping iron", the exercise of such brain areas on the right side increases their efficiency and size? Such speculation must be tempered by the fact that this is a University population of tyro mathematicians, still far from being able to even name themselves "mathematicians" without embarrassment). Walking early, early reading and writing and speaking early were associated; this latter grouping has around it some score reducing factors: most early walkers had artistic fathers, and early speakers tended to have reality loss in later life (45.161% of the whole sample had loss of reality, perhaps reflecting once more the proportion of artists), while early reading and writing were associated with not having familial allergies and asthma.

Season was associated with another advantageous characteristic, early perspective, more of the Winterborn (52.273% of the sample) having that precocious skill. Perhaps, as the artists dominate the early perspective category, the previously mentioned tendency to exaggerate early ability in individuals who, having other, lowered abilities (born in the Winter) need to bolster their self-esteem is sufficient explanation, if not a charitable one. The associations noted above between early perspective and clumsiness and allergy may illuminate this finding. 59.4% of the Winterborn had an Appositional cognitive style. However, the musical seemed less likely to be born in the winter months, in this sample.

The link between asthma and need to draw is surely explained by environmental means: the "creative sickness hypothesis" must come into play, isolation, bed-rest, inability to play sport-what else would the young asthmatic be able to do, except some paper and pencil work? Maths would be too much like hard work, too much mental energy required, so drawing is the obvious and preferred alternative. If a predisposition to artistic ability is enhanced by practice during asthma bouts, then it is likely that praise from parents (and sometimes doctors in attendance) will develop the *need* to draw from merely the liking to draw. It was not predicted in the hypotheses, although perhaps it should have been.

Having a single talent was associated with clumsiness, and so the General Hypothesis is upheld. Another known disadvantageous characteristic, the preference for black-and-white drawing, was associated with not being able to draw imaginatively, lending further support; the ANOVAs lend even more support, significant interactions seen between being in the low scoring 30, having been born in the late winter, and suffering loss of reality. The three most powerful variables with regard to placing in the top or bottom 30s, according to the Stepwise Regression, were math ability, eye colour, and myopia, which seems to lend great support to the much-maligned findings of Camilla Benbow with her precocious mathematicians, until, however, the figures are examined more "myopically": the association for myopia is, in fact, the reverse of her expectations, more of the short-sighted being in the low 30 scoring group. Eye colour was not found as one of her biological correlates with math ability. Perhaps myopia is associated with high cognitive ability in much the same way that sickle cell anaemia is intimately linked with protection from malaria in Africans. Benbow's other correlate, allergy, shows itself in this sample rather tenuously through the medium of an association of math ability and familial allergy. LWB is found in only 30% of those with math ability, providing some rather oblique support to Benbow's finding that most of her precocious mathematical youth were born in the summer months of June and July.

Eye colour, child illness, and allergies were the most influential variables on the two sequential sub-tests of the CLB: serial sounds and serial numbers. Allergy was associated with higher scoring, as were math ability and dark eyes, good eye sight and a healthy childhood. For the Form Completion sub-test, hand was an influential variable, left-handers scoring significantly (p<.02) better than right-handers. In accord with Geschwind and Galaburda's claims, and those of the many others cited and quoted earlier, hand was sometimes a usefully discriminating variable in this analysis, in asthmatics, mathematicians, and those suffering from a child illness that seemed likely to be of an immune or atopic origin.

Gordon found that the learning disabled scored higher on the Appositional tasks, something others have found, as well. He did not specify on what sub-tests they did well, however. Trying to find out what it is that may be associated with such a raised Appositional profile is a complex task. It is difficult to escape the conviction that the tests chosen by Gordon to tease out supposed right hemisphere functions may not be doing that alone; there may be two reasons for this: one, the sub-tests utilise left hemisphere skills to an extent, as well; two, the nature of the right hemisphere is more diffuse and overlapping (see the next chapter for a theoretical description of this) than the left hemisphere, which may consist of clearly sectioned and discrete units, and so the functions of the right hemisphere may be affected by more exogamous and endogamous variables. Overwhelmingly, the most influential factors were those identified as associated with the artistic subjects. For the whole CLB, the variables which were most influential out of 13 were the same ones. This may well say something concerning the predominance of Appositional dominance individuals in the sample. If all the factors which have shown themselves to be influential are considered, the strongest appear to be Eye colour and Mathematical ability.

Handedness Differentials On Appositional/Propositional Scores

The attempt to replicate with the CLB Levy's 1970 finding of greater difference between left-handers' scores on Verbal and Performance IQ tests than that between similar scores by right-handers provided some limited success with the hand variable. Again, the greatest contribution to the difference was not so much better scoring on the presumed right hemisphere tasks, but rather lower scoring by the left-handers on the Propositional or presumed left hemisphere tasks. This lends support to those who would argue for the pathological nature of left-handedness (Satz *et al*), poorer left hemisphere abilities being associated with left-handedness, rather than enhanced right hemisphere or symmetric functioning. Too much should not be made of this small difference; however, it inclines in the direction expected if we expect the left-hander to be less able in Propositional or Verbal abilities.

Subgroup Comparisons

When the sub-groups of Musicians, Artists, Mathematicians and Dyslexics are looked at, it is the performance of both the Musicians and the Dyslexics which are of interest: the Musicians are very little lower in score on the serial numbers sub-test than the Mathematicians, showing an excellent memory for strings of digits; could this be a talent carried over from their training in memorising musical scores? In the sequential tests the Dyslexics were poor, scoring below Gordon's norms, although the deficit averaged only .261.68 over the two tests. Mathematicians were once more the most able. Surprisingly, the Dyslexics did not average under Gordon's norms for the verbal fluency tests, the very ones it would seem most likely they would: they scored an average of .191. Next to the Dyslexics, the Musicians had the lowest scores.

Once more the Musicians were almost level with the high-scoring Mathematicians on the localisation sub-test. It is possible to speculate that their training was being tapped again, the skills involved in committing scores quickly to memory coming into use. On the orientation sub-test, the Dyslexics showed themselves less good than most, scoring below the norms, although only marginally (-.048). The literature tends to emphasise Dyslexics' enhanced spatial ability; the specifically spatial task proved hard for those Dyslexics in this sample, although it must be recalled that they were competing against undergraduates, and, in fact, did not score very much below the norms. The Artists and the Mathematicians were best at 3d spatial orientation, as was predicted.

It was in the form completion Gestalt sub-test that the Dyslexic group excelled, easily out-scoring the other groups. They were .453 ahead of their nearest rivals, the Mathematicians, and it is here that the superior Appositional scoring found in Dyslexics by Gordon must have it origin. Differences may exist, however, between the two samples, that in Scotland and that in the U.S.A.: in the Pittsburgh sample, form completion loaded across the two factors of Gordon's Factor Analysis, fairly evenly spread in its values (.296 and .319), something Gordon tends to explain by pointing to the verbal element in the writing and naming of the Form, whereas the Scottish Factor Analysis revealed that form completion loaded heavily on Factor Two and actually had a negative loading on Factor One (-.117 and .727). If Factor Two really is a right hemisphere or Appositional factor, it seems to confirm that this sample used wholly right hemisphere skills to master that task, whereas the Pittsburgh population used more sequential and verbal methods as well. If, as Gordon indicates, there is a verbal naming element to this sub-test, it is even more anomalous that the Dyslexics should do well at it! In another study, Gordon implies that higher scoring on form completion would be associated with lower achievement test scoring,[419] presuming that a visual-spatial profile would be counterproductive in most school subjects, although less so in mathematics. The dyslexics, in doing so well on the Gestalt test, emulated Hermelin and O'Connor's savants in their 1987 experiment, going perhaps some way toward confirming Gordon's claim. It is possible to speculate that both dyslexics and autistic savants exercise their visual-spatial constructive abilities more than normals, because they cannot use the more normal verbal constructive capacities of their presumably malfunctioning left hemispheres. Such strategies being difficult or impossible for them, they must use what they have, right hemisphere approaches which become highly developed through unusual use.

The Musicians were worst of all at the Gestalt test, further evidence that perhaps their best skills lie on the Propositional side. It must be recalled, however, that these are music theory as well as music practical students: music theory has been found to be

[419] Gordon, H.W., Specialised Cognitive Function and School Achievement, **Developmental Neuropsychology**, 4 { 3 }, 239-257, 1988.

processed in the left hemisphere; such students may have become more left lateralised than most professional musicians.
Another spatial test, Touching Blocks, showed the Musicians in a poor light, but the Dyslexics scored above the norms (.052), only fractionally behind the Musicians. On the Propositional scoring, the Dyslexics were, in fact, barely below normal (-.085), while on the Appositional scoring they were above the Musicians (.609 to .601). Given all the above, it was inevitable that the measure of lateralisation, the CLQ, would find the Dyslexics having the most right hemisphere dominance (.694) and the Mathematicians the least (.366). This sample has a 54% Appositional predominance, which appears as well in the right hemisphere dominance of all the sub-groups. In the above mentioned study by Gordon of 1042 children between 9 and 12 years, he found about twice as many who had a visual-spatial profile, even though they were as a population relatively above average in achievement tests.

The Factor Analysis of sub-group means found the Musicians to more closely resemble the Mathematicians. Shuter-Dyson and Gabriel cite Revesz (1953) as having found that only 9% of professional musicians had any mathematical talent, and that the result of correlating music and mathematics tests do not reveal any close connection. They say that perhaps in the early stages of learning music, as with learning number, verbal ability plays an important role,[420] although spatial ability, as with mathematicians, may play a greater part as they become more proficient. As all of the Dyslexics in their interviews heavily emphasised their artistic interests, it may not be a surprise in the end to find them loading with the Artists on Factor Two. None of the dyslexics who were tested on the CLB were left-handed, so it was not possible to look for a possible greater differential than the one found with the left-handers in the Levy semi-replication experiment.

Reaction Time And Eye Colour

It seems that the differences in reaction time speed found between the dark-eyed and the light-eyed in the two samples of University students follow the pattern found by earlier research, dark-eyed individuals usually being faster; however, the presence of a group of 15 very slow dark-eyed females in the 1990-1991 sample reduced the significance of their results. This may have been due to misclassification of their eye colour, something accomplished by a variety of means but which, in the interests of speed and simplicity (although perhaps not always in the interest of reliability), usually reduced to the judgement of the experimenter. Removing this group provided results which showed the expected differences, while reducing the validity of the experiment. Eye colour reaction time differences were obviously confounded with sex differences, the latter often being the stronger of the two influences. Males were clearly faster over all tasks; as may be expected, the dark-eyed males were fastest of all. All of this serves as support for the findings of the tests carried out with the Cognitive Laterality Battery, in that eye colour and sex not only identify those with higher or lower cognitive test scores but also identify those with faster or slower choice reaction times as measured by the Sternberg and McCarthy and Donchin tests. Most importantly, the same male, dark-

[420] **Ibid,** p.91.

eyed group are higher scorers and have faster reaction times than the female, light-eyed group. When two entirely different measures produce results which agree, the strength and meaning of both sets of results are multiplied. When the much less ambiguous reaction time results of the 1991-1992 sample are considered, as well, this message is reinforced.

General Discussion

Significant differences were found for eye colour, math ability, imaginative drawing, daydreaming, child illness, allergies, clumsiness, and many other somatic and psychological factors not only between the artist and the mathematician (or, at least, those in preparation to become those professionals) but also between those in the whole University population who scored in the top 30 and bottom 30 of the Cognitive Performance Quotient, a measure tentatively convertible to IQ scores. Had it been possible to check reaction time against discipline, it is suspected that the CPQ measure may well have been as well supported for that as it was for sex and eye colour, given earlier findings on the slowness of artists on paper and pencil tests. Possibilities for future research are easily imagined.

In general terms, then, the results provide ample evidence for the existence of characteristics which have not hitherto attracted a great deal of attention as possible markers or flags for lower cognitive test scoring, together with others which have had greater recognition. Mild pathologies and various constitutional and somatic variables have been shown to be associated with lower overall test scoring, with some of them clustering around differing cognitive styles and differing disciplines, such as art or mathematics, with greater implications for the reasons why individuals enter either of the two cultures of the Arts and the Sciences. The specific hypotheses have met with varying fates, but have generally been upheld; the General Hypothesis has similarly been supported. The Geschwind and Galaburda testosterone theory has found some support here, with asthma and eye colour, clumsiness and child illness, and to a limited extent with handedness; Benbow has found some support here for the association of allergy and mathematical ability, although other factors may mediate the relationship. The "Left Hand Pathology", where left-handedness was the most important unifying variable for a vast range of other pathologies and characteristics, appears to have been illuminated to a degree. There is a little support for the view that the left-handed are more visual-spatial, but what evidence there is here indicates that when this occurs it is due to **lowered verbal-sequential ability, and only rarely to enhanced right hemisphere capabilities**, thus confirming Gordon's findings with children with learning difficulties. Only the clearly identified dyslexics, with their truly outstanding Form Completion results, showed unusual and specific visualspatial ability; they, however, were not left-handed; in other groups, the small number of asthmatics showed a tendency to be left-handed. The relatively poor showing of the other right-handers on the Form Completion sub-test (.667 to 1.232), a right hemisphere, visual-spatial task, was not surprising, although it appeared that the left-handers in this sample clustered in the mathematically able group, who were superior in scoring overall; this may have enhanced the left-handers' scores.

Problems with this Study and Possibilities for Further Research

Sample size

It seems clear that the size of the sample used here was inadequate to fully identify the interrelations, associations and suggestive contrasts which seem to exist between the many variables examined in the research. The effects of some of the most interesting relationships are weak and a sample at least three times this size ought to be the target for a later investigation. Borderline or marginally non-significant findings may then harden enough for reliability-significance in a statistical test is, after all, merely another way of saying that the same result is likely should the experiment be carried out again.

Nature of Sample

The nature of the sample was quite special, full of hand-picked artists, psychologists, musicians and mathematicians (the dyslexics were not included in the overall analysis); as a result doubt is possible concerning the generalisability of the findings to anything else but a similar peculiar population. Not even a 'normal' university student sample would be the same as this one, although the intention was to accentuate the extremes to be found to a lesser degree in any such university student population, something which appears to have been successfully accomplished. The follow-up research should therefore be clearly identified as either looking at a truly normal, non-university student population or looking at artists, musicians, mathematicians, and dyslexics and perhaps autistics in much larger groups-7 to 14 in a group is simply not sufficient for firmly reliable conclusions to be drawn from any analysis of their data. The wide variation in the scoring of these groups in the present study tends to undermine the significant results, while still allowing the conclusions which have been drawn to act as indicators for further research.

Suitability of Statistical Methods

More suitable statistical methods ought to have been used: path analysis may well have provided a clearer overall picture of the multiplicity of relationships which appear to exist between the variables examined. It could have provided a measure of the weightings of the relationships between the variables. Further, the use of t-tests following ANOVAs is not a recommended practice: the nature of the t-test is always likely to enhance, sometimes erroneously, the probability of significant differences being found in pairwise comparisons-Tukey, Neuman-Keuls, Scheffe F-test, or the Fisher PLSD test should be used to be more correct. This does not apply, of course, to those ANOVAs recorded here where such *post hoc* pairwise comparison tests **are** used as part of the statistical program. Greater trust may be placed in the results from those. Such was the variance in some of the populations (such as the light-eyed) it may well have been argued that nonparametric, rank-ordered tests should have been used, rather than those which presume a normal distribution. It appears, however, that the majority of the populations (such as the dark-eyed) were homogeneous enough for this to be a minor doubt, overall, especially as the only associations which were examined in detail were those identified by Chi-square tests first.

Future Research

Enough was found, however, to encourage the present writer to pursue further this line of inquiry, perhaps narrowing the areas of investigation to those where the most suggestive results were found: eye colour, clumsiness, asthma, allergies, child illness, daydreaming, mathematical ability, doodling, etc. These seem to show exciting promise, revealing relationships between variables where relationships had not hitherto been suspected. The present research has the 'feel' of a 'pilot study' which tested a questionnaire and a cognitive battery which both need much more use for proper evaluation, and which ventured into some very contentious areas with more recklessness than wisdom. If this was an exercise in Kuhnian paradigm-breaking, then now is the time for some "Normal Science", taking each relationship and examining it with more coolness and over a longer time-span, with a view to establishing its solid and reliable existence or not, fitting it into the jigsaw of a paradigm which at the moment appears rather jumbled.

A positive aspect to the present research is that the questionnaire was devised before the existence of the CLB was known -it follows that the items in the former qualitative instrument could not show the influence of the researcher's knowledge of the tool which was to be used to produce the quantitative data. Even better, the subjects could not possibly 'second guess' their answers to the questionnaire from knowledge of their experience of being tested with the CLB, or vice versa. The categories derived from the questionnaire items were very often so unusual that their application to the number data could not possibly have produced any bias in the results-apart from the handedness items, there was only a very tenuous connection between the instruments. The consequence is that when some of the more peculiar results are considered (e.g., from month of birth, eye colour) they must be taken with more seriousness than they at first appear to deserve, especially when concatenations of variables begin to gather together which have validity from clinical or neuropsychological research, such as those used in Geschwind and Galaburda 'testosterone theory'.

It remains, as well, that there exist some 216,000 words of transcribed interviews, containing a richness of qualitative material which this thesis has hardly utilised or begun to describe; the categories used to divide the CLB scores are pallid and sadly restricted nominal quantities abstracted from qualitative accounts full of colour and individuality, accounts which, edited with sensitivity, could form a British follow-up to Bloom's well-known accounts of creative individuals in North American colleges. Not enough was suggested in this thesis of the nature of the vast body of information on which the categories examined were based; they were not simply plucked from thin air. The pilot study detailed earlier may give some flavour of what could have been, and may still be, a twin thesis to this one.

Further, many more categories exist in this body of work which were not used in the analysis: as the original questionnaire shown within the pilot study report indicates, subjects were asked about topics such as:-

Sporting skills

'Party trick' skills such as handstands/other unusual motor abilities

Earliest art/math work

Earliest realistic art work
Method of holding drawing instruments
Speed of drawing
Parental encouragement/pushing toward a career choice
'Card index' of images
Illustrator or storyteller approach to art
How music is experienced
Visualisation in mathematical working
Familial handicap
and others.
These, too, could be used to divide the CLB scores and thus increase the all-round picture of these individuals.
Clearly, if the above categories and those already studied are used, this research could generate a considerably greater quantity of potentially publishable, worthwhile work.

If the more qualitative work carried out with the artistic savants is critically examined, it may be seen that there was a failure of imagination in devising adequate methods of testing such fascinating and inspiring individuals. It is no comfort to the present writer that this failure of imagination has been shared by all other investigators in the past-it was always the intention that this time the task would be more adequately carried out. Sadly, such was not the case: faced with the impossibility of getting meaningful results from the savants using the CLB, a mish-mash of other neuropsychological tests, scans, RT. and psychometric tests were attempted, which brought forth little new and little which could cast light on the nature of such individuals generally. Although the NMRI scan was, it appears, the first ever carried out on a savant (several have been carried out with autistsics *per se*) on its own it is not very informative, except negatively-the only conclusion possible to draw from it is that at least this particular savant has a great artistic ability and severe cognitive deficit without either having obvious neurophysiological origins on a brain scan. The descriptive information was perhaps of some worth. Eight hours of video tape exists of Richard Wawro producing an Ecuadorian landscape which is waiting for micro-analysis, in order to arrive at a breakdown of savant artist production methods. Similar video tapes exist of Andrew and two other autistic/handicapped artists. Further research should involve making similar video tapes of 'normal' artists producing their work, so that comparisons can be made with savant production methods, which appear to be unusual in several ways (instrument hold, closeness of the eyes to the paper/canvas, position on the paper at the start, order in which drawing elements are produced, apparent 3d visualisation which allows the covering of detailed elements which will never again be seen but which have been considered 'necessary', and so on).

The first year of this research was concerned with visiting nursery and junior schools in the Lothian region seeking precocious artistic talent; a considerable amount of information was gathered, although few truly precocious artists were found. Research in this area was curtailed when it was realised that a three- or four-year research project was not going to be long enough for proper completion of such an enormous survey by one person. Further research could take the form of a team of investigators looking not only at early artistic but also early mathematical ability; this could have some relevance to the question of the usefulness of age-specific tests. One truly precocious artist, Scott, was found; again, a video tape exists of him producing excellent drawings, and, quite by chance, a truly precocious musician was found, too: John (Once more, the CLB test scores of these two children of 10/11 years were not used in the analysis). These both had characteristics which were clearly very apposite to the Geschwind and Galaburda theory, one so severely afflicted by asthma before the age of ten that he almost died, the other suffering pervasive developmental and attentional problems which produced immense difficulties at school. A 'talent search' ought to be begun to find similarly talented individuals, in order to check the prediction of the testosterone theory that such children may often display similar disadvantageous characteristics.

It is probably a truism of all research projects that the piece of work which eventually emerges from it represents, like the proverbial tip of the iceberg, but 1% of the total amount of material gathered or the possible lines of work it suggests. This has been no exception, and such may be to its credit.

Overview

Environmental Influences

Given a basic genetic template, which varies little between individual human beings, all should develop the optimum capabilities inherent in them. It does not seem likely that human DNA carries within it the sort of instructions which would ultimately result in the almost infinite variation in capability observable in humans and other animals-99% of human genotypes are identical; however many permutations are worked on the four basic biochemical elements in DNA, they do not seem adequate for the enormously complex job. Even with the simplifying help of multiply-self-duplicating self-similarity, as seen in the morphology of the lung, pancreas, kidney, arterial system, and brain, the instructions from the DNA cannot spell out in every detail the talents or skills or disabilities and incompetencies of each individual. Social forces clearly have a great part to play in shaping the human being, and yet they are too diffuse, too distant in terms of cause-and-effect to be accurately identified, quantified, predicted. More immediate environmental influences, mostly deleterious, must be cited as the most important sculptors of the primal human genetic clay.

From the moment of conception, then, the foetus is subject to any number of capability-reducing influences: the inherent genetic influence of possible Down's syndrome, Rett's syndrome, phenylketonuria, sickle-cell anaemia, hereditary dyslexia, myopia, asthma, and many other ailments; the influence of environmental pollutants on the mother, such as lead, radon, strong electromagnetic fields, industrial waste; the influence of smoking, alcohol and other drug abuse, together with immune system disorders, influenza, and other viral infections; poor nutrition; the administration of potentially harmful drugs such as diethylstilbestrol to prevent miscarriage, and the possibility of premature birth through poor hormonal balance in the mother, or through stress. Birth trauma, the risk of anoxia through cord strangulation or other "difficult" birth incidents, including forceps delivery with its possible deformation of the soft skull, produce perinatal deleterious effects. Immediate post-natal infections, jaundice, colds, have their effects, too, as do the vagaries of the feeding process: the mother's milk may not contain adequate T-lymphocyte stimulating elements to stimulate the infant's immune system. A northern geographical situation may expose the infant to a higher risk of viral infection, later schizophrenia or multiple sclerosis. Poor child care, or even abuse may reduce the chances of the child developing what remains of its original potential, together with ineffective schooling practices and inadequate teaching. The child, having received one wave of deleterious affects in the womb, receives the second wave in its own right from a polluted environment, further reducing his/her potential abilities. This gloomy process continues throughout life, the initial surge of bodily vigour gradually petering-out, like a small wave on a barren shore.

Development runs counter to the constant bombardment by disadvantageous influences, organising, constructing, maturing both brain and body; however, development is possible only for those brain and body areas which are whole. Such is the plasticity of the brain when young that faults can be patched-up, the neural "wiring" re-routed around the damaged area, or a secondary system in another hemisphere may develop in its place. Nevertheless, there is a limit to this "make-do and mend" strategy because the patches are never as strong as the original material: the re-routing never quite produces the same efficiency of function, the alternative brain area is never quite as good at the job as the correct area would have been. After early adolescence, even these stratagems cease to be possible. Old age and the quite swift acceleration of decrepitude and decreasing ability may then be seen as a more dramatic revelation of a process which has been at work since conception. The whole process from conception to death may be seen schematically as two opposed arrows, one marked "Natural Vigour and Development" and the other "Disadvantageous Influences and Ageing"; all human beings are situated throughout life at the constantly fluctuating conjunction of the two arrowheads. In health, we are in sickness; in sickness, we are in health, just like Sacks' post-encephalitic patient. The human tragedy has always been that we know none of us ever fully recovers: the malady of life is always terminal.

<u>The Sociopathic Generations</u>

One of the most interesting, although tentative, conceptions which arise from this research is the apparent linking of the autistic, Asperger's Syndrome, psychopathic, train spotter/absent-minded professor, individuals along a continuum of reduced ability to treat others as human beings with minds and feelings just like their own. In these groups it seems those evolutionarily recently developed brain areas responsible for a 'theory of mind', empathy, or recognition of the Other appear to be immature or damaged. Those areas of the forebrain and temporal lobes which are the last to develop in the foetus, neonate and infant may be essential for full social functioning. If that is the case, perhaps a connection may be found between influences such as environmental pollution, poor maternal nutrition, alcoholism, 'hard' drug-addiction, smoking, illness, the child's season of birth, and later antisocial, criminal behaviour, the callousness, casual violence and aggressiveness of the generations born into a steadily worsening environment. The current debate about the debased moral nature of today's youth may not be simply that often encountered belief of an older generation that the children of today are inferior to those of thirty years before, but rather have at its base an element of real difference-today's hyperactive, short-attention span, innumerate, often illiterate, bad-tempered, cruel, greedy, impatient, unloving, unhealthy children may be like that not because of any bad parenting brought about by the abandonment of pre-1960s standards, but through the subtle and insidious work of all the deleterious influences already identified. For many children it may be that their brains have simply remained immature in some small but vital way; their full maturity is retarded in the old conception of mental retardation, but not necessarily in the area of intelligence alone.

Where does the artist stand on this continuum? The artist may be seen as somewhat off-centre, closer to the autistic and the train-spotter, although still, in most cases, within the normal range, but considered eccentric, both by themselves and by others. This is not a new conclusion, but it is one which nothing in the present research has disconfirmed. The stereotype seems to have gained a little more reality from the evidence here.

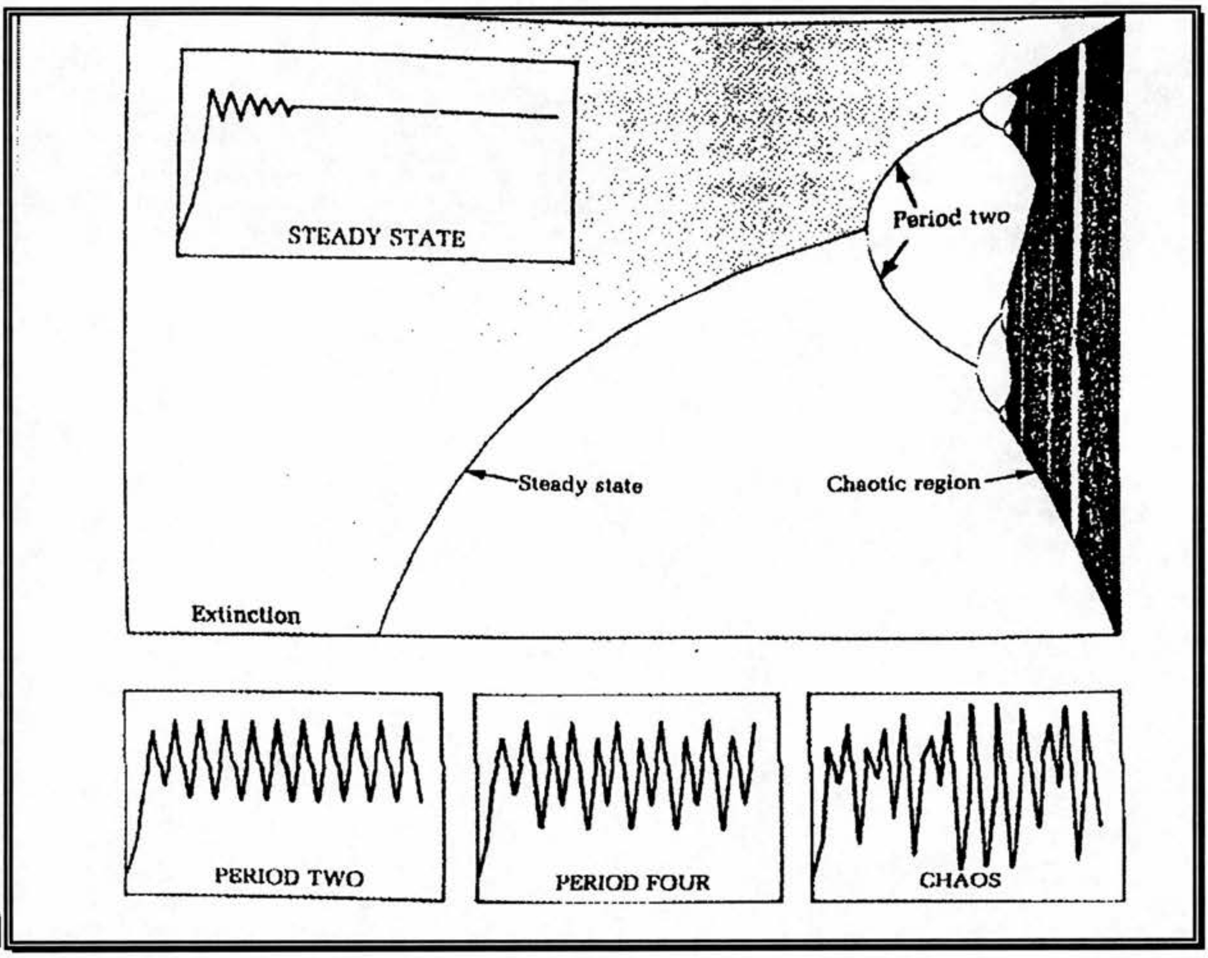
The "gifted" individual, however, is clearly one who has not been visited by a mysterious Talent Fairy, but simply someone for whom the environmental and genetic dice have fallen favourably, allowing him or her to retain more of the original potential possessed by most human beings. If all things were equal, everyone would be a genius (and, therefore, the term "genius" would not exist); unfortunately, equality is an ideal never achieved. The savant, conversely, has seen the environmental and genetic dice roll to low numbers in all but one throw. For most people the numbers thrown vary between "quite good" and "quite bad", while the dyslexics have to live with one terrible roll of the "bones". Einstein, when faced with quantum mechanics, said that God does not play dice: all the evidence seems to disagree with that statement. The theme for this wide-ranging research thesis was " Tho' much is taken, much abides", and it must be emphasised once more that for all the deleterious effects identified, this University population functions very well, will generally achieve their degrees and go on to have successful and, let it be hoped, happy lives. We "...strive, to seek, to find, and not to yield."

Diagnostic Categories

Concerning the permeability of diagnostic categories, it seems clear that if the massively complex interaction of factors evidenced here is the usual state of affairs, and not simply an artefact of possibly both theory and method, then those neat, clean definitions that pigeonhole people as having one pathology or another, or being one sort of person or another, seem artefacts themselves, produced by the analytical, pigeonholing left hemisphere processing which so dominates Western culture. While this thesis appears to have followed a similar classificatory route in trying to define correlates of two pigeonholes, "artist" and "mathematician", it has been the similarities between them which have been the most gratifying. Indeed, given the basic thesis, that we begin whole, like some block of marble or mound of clay, and are then sculpted down by time and fate to our own peculiar individuality, it would be extremely difficult to devise any taxonomy for us all which did not leak.

Lateralisation of Function

With regard to lateralisation of function:-it is still an area in which much dispute rages. From the phrenology of Gall in the 19th century, through the holism of Lashley, to the dichotomised brain/mind of Bogen and Sperry, views have changed. From a patchwork quilt of strictly localised functions, to a "two-cylinder machine", which works best when both sides function in unison and cooperate well. Since the beginning of the 1980s, however, there are strong signs that the two sides are ready to dissolve once more into many facets, that "two" is no longer **the** number, due to the difficulty found in identifying functions which will confine themselves to one or the other hemisphere. A multiplicity of elements of brain functioning may now be preferred, casting doubt on the theoretical validity of instruments such as Gordon's Cognitive Laterality Battery. Indeed, it was the awareness of the present writer that such was the prevailing **Zeitgeist** which led to such close interest being taken in the various sub-tests of the battery, and the varying effects on them exerted by the different characteristics examined. The dice may fall, a module may suffer, rather than a hemisphere: some modules may be more significant to human cognitive functioning than others, as the left hemisphere seems more important to proper human functioning in Western culture. Indeed, it is possible that more of these "culturally important modules" may have most or all of their neural embodiment in the left hemisphere. If, however, the sub-tests represent some more relevant reality of brain and mind functioning, perhaps mapping-on to a modular structure, deeper mysteries still remain concerning such modules' organisation, the ways in which they are individually put together, their reason for existence. After all, for the dichotomised brain there is a clear and obvious anatomical justification: the "walnut" has two lobes. There are no such obvious or visible justifications for the proposed modules. These are matters into which the next and final chapter will attempt to look, and in so doing produce an overview of psychoneural functioning which may both explain modules and allow the existence of lateralisation of function.


STEADY STATE
Period two
Steady state
Chaotic region
Extinction
PERIOD TWO
PERIOD FOUR
CHAOS

NON-EQUILIBRIUM SYSTEMS AND THE BRAIN

In the light of all the foregoing, the need to conceptualise such a highly differentialised structure and process as human psychoneural functioning in terms of modularity theory becomes even more essential. Nevertheless, a certain basic problem seems to exist with regard to how modules or intelligences come into existence. What organises the neural networks, the connections between brain structures which subserve each psychological module?

It is not enough simply to point at the neural connections and say "You do not need anything more than these", because they tell us nothing about the true nature or origin of mental organisation; they are not transparent, they do not bear labels telling the observer what thoughts are passing through them at any one time. A description of thought is ludicrously inadequate if it is attempted at the neurophysiological level only. We see the morphology of the brain, the neural connections, the differing structures, and assume that it became organised in that way partly from genetic "blueprints", instructions in our DNA, and partly from some ordering and weighting process derived from the frequency and intensity of electro-chemical impulses. We deduce by association, different measures of activation apparently coinciding with different behaviours, different disabilities apparently coinciding with different lesions or diseases. Nevertheless, such a way of seeing brain organisation refuses to acknowledge its identity with all other systems made up of interconnected units, and the obedience they must show to the known physical laws. Organic or inorganic matter, these laws govern them both.

An example used by Richard Dawkins to illustrate what he sees as the self-evident difference between animate and inanimate matter is that of the bird thrown into the air: it will not show the same obedience to physical laws as a thrown stone-the bird will fly, the stone will fall-but the bird flies only by utilising physical laws, albeit different ones to those attempting to pull it to Earth. We think utilising physical laws, our organic, intentional selves constructed according to their dictates and organised in the manner in which most of the material Universe is organised. Indeed, it may be that our intentionality itself, our ability to decide on a course of action, is a function of the way in which our brains are organised.

By the principle of isomorphism, neural connections seem both to be dictated by and to dictate mental organisation: by thinking we minutely change neural connections and their weightings, and our neural connections channel our thoughts. Modules, therefore, are both child and parent of themselves. It may be asked, "What holds them together?" Phrased another way, what boundary conditions maintain their parameters? Answers may be drawn from a study of contemporary physics and biochemistry, and particularly from the nature of what are known as "self-organising dynamic systems".

Synergetics is the study of dynamical, self-organising systems. It seems that systems made up of a multiplicity of similar units interconnected with feedback, such as the stellate corticocortical cells (the cells which connect with each other within the cerebral cortex), can be pushed to a state of non-equilibrium if enough neural energy flows through them. From a stable state, such systems reach a level of what is known as **period-doubling**; at a certain value of the energy level of the system it may take two forms, and oscillates between the two states; at a greater level of energy more possibilities are open to the system, and so it wavers between all of them. These are known as **bifurcations**, and may be demonstrated by the now well-known fig-tree chart.

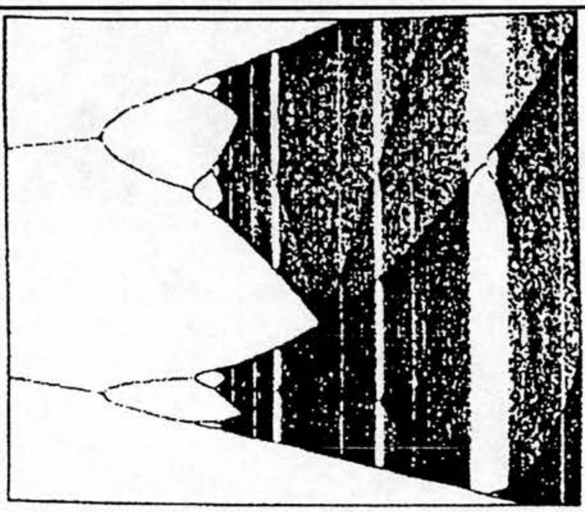


FIGURE FORTY-ONE: BIFURCATION DIAGRAM; A FIG-TREE OF PERIOD DOUBLINGS, FOLLOWED BY CHAOTIC BANDS. [ADAPTED FROM STEWART, 1989]

An infinity of choices, or bifurcation branches is reached, when true chaos begins [**FIGURE**]. At one of the earlier, more stable levels, however, new and more complex organisation can be attained, what may be called "weak" chaos.

One of the characteristics of this fig-tree chart is that it is **self-similar**: if one were to magnify any part of the multiplicity of branches, down to the smallest visible one, it would still look very like the larger one. This can be seen if satellite photographs of shorelines, with their peninsulas and coves, are magnified over and over again: at every magnification they seem just like the original, until if one were to kneel down on a rocky shore and examine the rivulets and fingers of rock and sand at one's feet, they, too, would look very much like the satellite photograph. Trees manifest the same curious structuring, in both roots and branches. This is what is found in the fascinating Mandelbrot Set, the almost infinite reduplication of crystalline shapes from the macro to the micro levels.

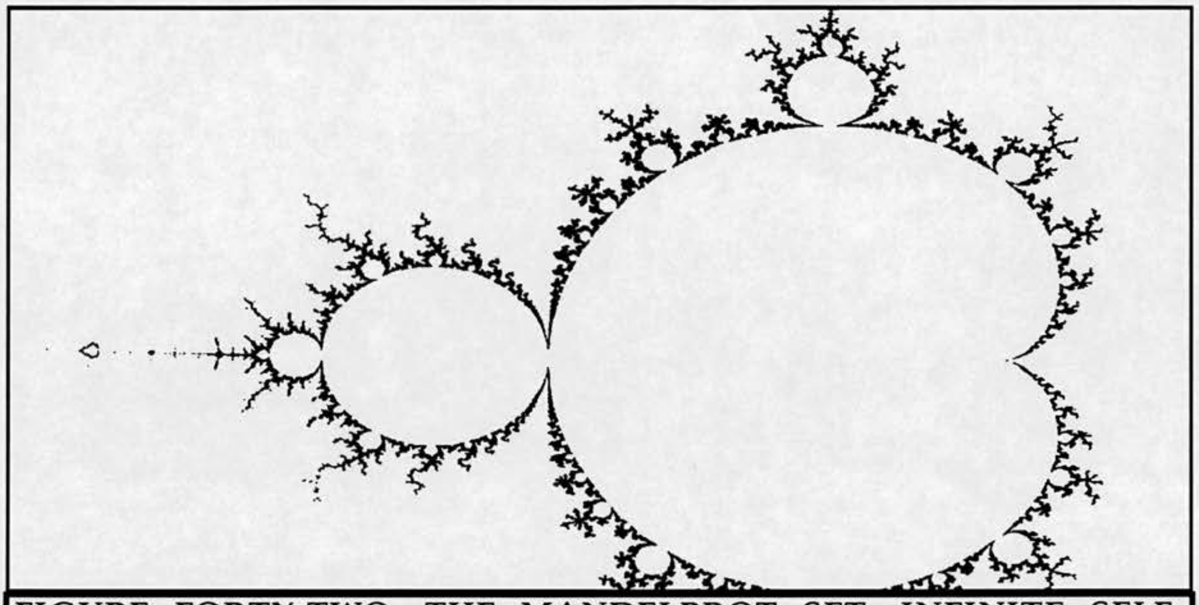


FIGURE FORTY-TWO: THE MANDELBROT SET: INFINITE SELF-SIMILARITY [ADAPTED FROM GLEICK, 1987]

Self-similarity can be seen, too, in the human body: in the villi of the intestines, in the bronchial branchings of the lungs, in the "coastline" structures of heart ventricles, in the urinary collecting system, in the arterial and venous system with its multiply branching capillaries, in the pancreatic ducts Teresa Ree Chay and John Rinzel have found chaos effects in the self-sustaining oscillations exhibited by the pancreatic Beta cell[421] and in the structure of neurones in the brain.[422] Every part of us seems touched by the hand of Chaos; indeed, we seem to be very much creatures of Chaos.

Accurate computer simulations of trees, plants, shorelines, and mountain ranges have been created solely by the use of simple equations based upon the principles of self-similarity and Chaos Theory.

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421 Chay, T.R., and Rinzel, J., Bursting, Beating, and Chaos in an Excitable Membrane Model **Journal of the Biophysical Society**, Vol. 47, pp. 357-366, March, 1985.

422 Goldberger, A.L., and West, B.J., Fractals in Physiology and Medicine, **The Yale Journal of Biology and Medicine,** 60, pp. 421-435, 1987, and Goldberger, A.L., Rigney, D.R., and West, B. J., Chaos and Fractals in Human Physiology, **Scientific American**, February, pp. 34-41, 1990.

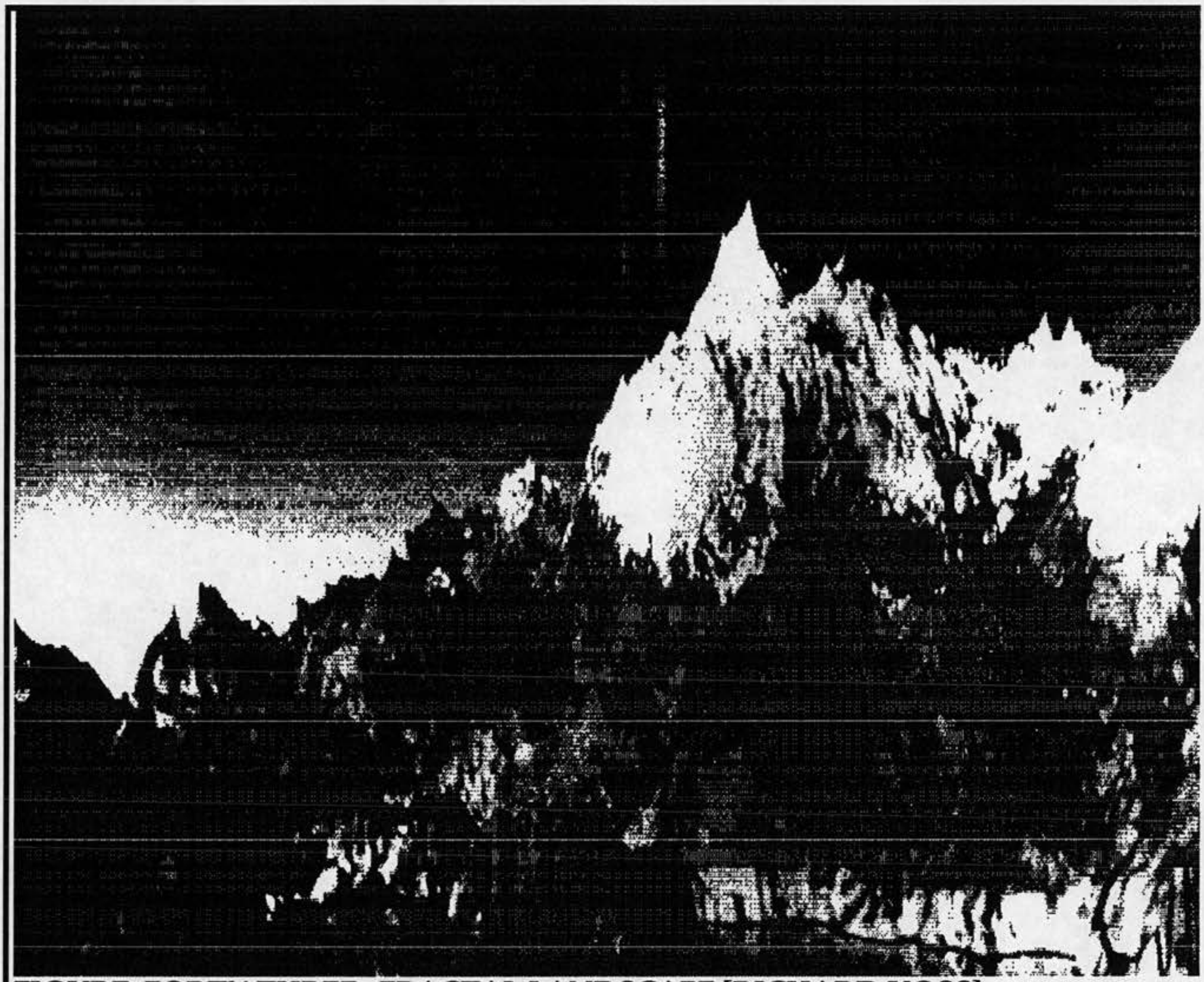

FIGURE FORTY-THREE: FRACTAL LANDSCAPE [RICHARD VOSS]

Small changes in the original values of the equations produce large differences in the structures which emerge, a demonstration of the well-known "Butterfly Effect", first heard of in relation to the obvious failings of weather forecasting: the twitch of the wings of a Red Admiral in one hemisphere may ultimately produce a hurricane in the other hemisphere. Moreover, such large differences in outcome from such very small causes may go some way toward explaining how the relative simplicity of our DNA code can produce such complex creatures as ourselves. If we are largely built on the principle of self-similarity, that would relieve our genes of much of their present responsibility: the development of brain and body could be set in train by small changes in our "genetic equations". How can we doubt that such a potent and omnipresent force does not affect the way we think and the organisation of our minds?

Systems may move down the "fig-tree" toward true chaos and disorganisation, or they may reach a point of dynamic balance at a higher level of organisation than their previous state. As Leonardo da Vinci noted, water contains both chaotic turbulence and organised, if ephemeral, systems. The rushing river is creative in the sense that it can produce self-organised fluid structures; however, too strong a current produces formless turbulence, while below a critical threshold the flow is smooth and featureless. Dynamic systems can organise themselves only so long as they are open to their environments: energy must be able to be **dissipated** to allow any perturbations which may occur to the orderly structure of the system to be damped down. Energy must be constantly supplied to allow the dissipative system to survive. It follows that if we are saying that modules are self-organised by such a process, they must always be open to neural energy, to flow through them and to cause them to retain their organisation, like the vortices and whirlpools in a flowing stream. If a system is closed organised activity decays in accordance with the Second Law of Thermodynamics. Clearly, modules cannot be closed systems.

Non-linear Dynamics Research And Recent Modular Theories

In a recent conference report[423] it was noted that researchers were using non-linear dynamics to explain psychological phenomena such as the emergence of behaviour in neural networks, infant motor development, control of co-ordinated hand movements, and the development of learned skills. Schoner and Kelso had proposed a "bridge" between dynamical systems theory and cognitive science, "...enhancing our understanding of complex, **learned** coordinations, such as piano or cello playing, that develop out of more primitive, **innate**, phasic organisations".[424] Szu, of Grossberg, Shimizu, and Szu, attempted to define neural networks/modules, and the essential features of the brain which allow separation into different functional systems; he stated that they were:

Non-linear;

non local;

non stationary;

nonconvex.

Although the exact meaning of the last definition is somewhat opaque, the others substantially agree with the metaphor/model which will be put forward shortly. The report concludes:

> ...a Kuhnian paradigmatic shift is taking place in medicine, physics, chemistry, biology, and mathematics. The implications of this work within the field of psychology are not yet apparent... But consider the possible rewards. First, non-linear models, which are more powerful than linear models, allow explanation of types of behaviour and cognitive processes that have resisted interpretation within linear frameworks. For instance, it is impossible to explain the spontaneous emergence of structure in a linear model, although this kind of sudden self-organisation is almost certainly

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423 Metcalfe, J., and Merrill, J., 1987 Conference on Dynamic Patterns in Complex Systems, **Psychobiology**, Vol. 16, 1, pp. 75-78, 1987.
424 **Ibid**, pp. 76-77.

widespread in human thinking and behaviour. Investigation of the possibility of such phenomena within psychology has been restricted, perhaps because of a false belief that emergence of new structure was not only unscientific but also theoretically impossible. Second, the fact that dynamical systems are **intrinsically** temporal corresponds to the inherently temporal nature of human cognition. Thus, in building models in this framework, we need not add the temporal dimension in an *ad hoc* manner, as is usually done with linear models. Third, the ability to deal with complex systems in a natural and analytical way provides a means whereby the brain-in all its manifest complexity-can be modelled in a principled manner....There are those who would argue that the human being is the epitome of complex patterning dynamical systems. If so, then the potential enhancement of our understanding of human cognition that will result from the study of Synergetics will almost certainly repay the most diligent effort.[425]

Brent and others have begun studying the possibility of just such a "bridge" as was mentioned above.[426] Molenaar (1986) criticises Fodor's claim that modules/neural networks must remain simple, incapable of self-organisation.[427] He states:

If an increasing number of associations is established, then the network can give rise to a so-called limit cycle...that globally modulates the existing structure of associations. This means that a qualitatively new type of coupling between the constituents of the network emerges, i.e., the local associations integrate into a more powerful structure. Notice that the emergent integration is induced by the structure of already existent associations itself (genuine self-organisation) and is not due to the taking effect of some innate law... The emergence of new limit cycles can repeat itself several times...each time adding oscillations of different frequencies that invoke a renewed integration of, and add a new modality to, the network. Consequently, the evolving non-linear network will build up complex concepts, the organisation of which transcends the originally given associative couplings...the network is capable of acquiring more powerful structures.[428]

and

Not only at the level of synaptic transmission, but also at lower levels of biochemical regulation...or at higher levels of neural mass action...the central nervous system appears to be inherently non-linear. Hence, the emergence of qualitatively new properties is not bound to a particular level of neural implementation...the capability to sustain an evolving sequence of more powerful structures seems to be a generic characteristic of the central nervous system.[429]

Feedback causes self-organisation. This can be demonstrated when a video camera is pointed at its own monitor screen: order and structure develop spontaneously, wheels, spirals and mazes developing from chaos. Such a complex, dynamical system can be further disturbed by perhaps using a zoom mechanism, changing the parameters of the system, driving it further from equilibrium, eventually reaching another point where bifurcations can occur (The above is drawn from Paul Davies'

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425 **Ibid**, pp. 77-78.

426 Brent, S.B., Prigogine's model for self-organisation in non-equilibrium systems, **Human Development**, 21, pp. 374-387.

427 Molenaar, P. C. M., On the Impossibility of Acquiring More Powerful Structures: A Neglected Alternative, **Human Development**, 29, pp. 245-251, 1986.

428 **Ibid**, p. 249.

429 **Ibid**, pp. 249-250.

Cosmic Blueprint, Heinemann, London, 1987, and Ilya Prigogine and Isabelle Stengers' **Order out of Chaos: Man's new dialogue with nature**, Flamingo/Fontana, London, 1984/5, two books which give a clear and adequate summary of most aspects of the New Physics, as it has been called).
Paul Davies, a populariser of the New Physics, says:

> The degree of complexity in living organisms far exceeds that of any other familiar physical system...At every level, and bridging between levels, is a bewildering network of feedback mechanisms and controls...At each new level in complexity in biology new and unexpected qualities appear, qualities which apparently cannot be reduced to the properties of the component parts...No living thing exists in isolation. All organisms are strongly coupled to their inanimate environment and require a continual throughput of matter and energy...each organism is strongly out of equilibrium with its environment...(pp.94-95)

Davies quotes Karl Popper as having seen lasers, diffraction gratings, and holograms as examples of large-scale complex structures which constrain the motions of individual photons to conform with a coherent pattern of activity. Hierarchical organisations are created when smaller units integrate and aggregate into larger units, giving rise to new rules which in turn constrain and regulate the component subsystems to comply with the collective behaviour of the whole system. Downward causation is a function of feedback systems: when a power grid is supplied by a single generator, the frequency of supply is likely to drift due to variations in generator output. Coupling many generators into the grid stabilises the oscillation frequency by pulling any drifting generator into line with the rest. This is an example of how a system constrains and guides its individual components to comply with a coherent collective pattern; Huygens discovered this principle of "entrainment" 300 years ago, but it is another example of self-organisation.[430]

Davies goes on to things cerebral:

> ..the brain can be regarded as a fantastically complex *network* around which electrical *patterns* meander. If, as seems clear, mental processes are associated with patterns of neural activity rather than the state of any particular neurone, then it is the latter approach that is most likely to illuminate the higher functions of behaviour and consciousness...Neural anatomy is awesomely complex. The human brain contains some hundred billion neurones and any given neurone may be directly connected to a great many others. It seems probable that some of the interconnections are structured systematically, while others are random. The electrical output signal of a given neurone will depend in a non-linear way on the combined input it receives from its connected partners. These inputs may have both an excitatory and an inhibitory effect. Thus, the character of the output signal from a particular neurone, such as the rate of firing, depends in a very complex way on what is happening elsewhere in the system. It is no surprise that a system with such a high degree of non-linearity and feedback should display self-organising capabilities and evolve collective modes of behaviour leading to the establishment of global patterns and cycles. (p. 184)

How is this process applied to modules? It seems clear that modules change with development, different brain structures being involved in the production of similar

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[430] Davies, pp. 149-150.

behaviours at different points in the human life span. For this reason brain lesions in the same areas in the child and in the adult produce differing disabilities, or disabilities that do not manifest themselves until that particular brain area is required to link up in a particular module, or do not manifest themselves as severely because sufficient plasticity exists in the child's brain to allow it to allocate other areas in place of the damaged one. Luria discusses this at length in **The Working Brain** (1969).[431] Thus a module cannot be rigid or enclosed, nor is it made up of Fodor's "fixed neural architecture". The micro-organisation of the cortex and to some extent the sub-cortical areas must be in a constant state of flux, with stability resulting from competition, co-operation, and moderate energy levels. Increasing use probably increases the space required by a particular module, incorporating more neural matter-conversely, decreasing use will decrease the neural matter required. Improvements which occur in perceptual and motor skills with practice, and the remarkable recoveries which often follow central nervous system injuries may be explained by this mechanism.

Mountcastle[432] suggests that assemblies of his small modular cortical columns linked together by input-output connections form larger units that are reflected in cytoarchitectural differences between brain areas: such multiply interconnected subsets of modules possibly play a part in many different functional systems. He says:

> *Such a distributed system is conceived to serve a distributed function.* A single module of an entity may be a member of several (but not many) such systems. Only in the limiting case might all the modules of an entity have identical connections.[433]

Modules may therefore be organised at the level considered by Mountcastle, in terms of his columnar cortical structures, or at the level of neuroanatomical structures and their connections, or both. If elements of different modules are shared by others, it will be a very difficult matter to delimit any one module in the rigid, Fodorian manner, or by the strict localisation of function approach of some neuroanatomists; any metaphor or model which hopes to more closely approximate the actual dynamic, changing, shifting processes of the brain must be as fluid and dynamic as that which it seeks to describe.

Kaas (1987) points out that neurones and neural connections in the developing nervous system are superabundant, with the neurones in competition with each other for synaptic space and survival; co-activation of inputs results in a selective increase in synaptic efficacy and survival. He postulates the existence of functional heterogeneity permitting parallel processing of information, with independent channels or types of processing modules. Most processing is concerned with a single

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431 Luria, A.R., **The Working Brain: An Introduction to Neuropsychology**, Translated by Basil Haigh, Penguin Books, 1973.
432 Mountcastle, V.B., An organising principle for cerebral function: The unit module and the distributed system, In G.M. Edelman and V.B. Mountcastle, editors, **The Mindful Brain**, Cambridge, Mass., MIT Press, 1978.
433 **Ibid.**

modality, but even simple attributes of stimuli in, for example, perception (colour, motion, form) are unlikely to be based on processing within a single "field", with each activated area contributing to the resulting perception. Kaas goes on to say that the micro-organisation of the cortex is constantly in a state of flux, with stability resulting from a balance of competing factors:

Receptors activate cortical space to an extent that is influenced by competition between inputs and relative use, so that increasing use probably increases cortical space and decreasing use probably decreases cortical space. Such a mechanism could account for the improvements in perceptual and motor skills that occur with practice, and the remarkable recoveries that often follow central nervous system injuries.[434]

Oliver Sacks has written concerning the radical adaptations shown by deaf children who use sign language: they become intensely visual, developing great physiological enhancements of visual perception, visual imagery, visual memory, and visual-cognitive powers as they acquire the sign language:

Visual functions which are normally lodged in the right cerebral hemisphere cross over and get relocated in the (more analytic) left hemisphere; and most remarkable of all, cerebral cortex which is normally auditory in function is reallocated, and completely turned over to visual processing. Deaf signers thus develop, under the spur of experience, radically new forms of neural organisation, neural mappings, which allow them to categorise the world in a quite novel way. This would be wholly impossible if the circuits of the cerebral cortex were fixed and programmed in advance. What we see is that the opposite is true, that huge areas of the cerebral cortex are plastic at birth, open to a great range of possible developments, the actual development depending on the experience of the child.[435]

Such ceaselessly altering, moving, enlarging, shrinking forms seem most aptly described only in terms of self-organising dynamic non-equilibrium systems. Box and arrow diagrammatic models cannot adequately explain such fluidity, nor could the more recent connectionist or parallel distributed processing models, which do not take account of the feedback actually encountered in the human brain. Such programs have great problems with novel stimuli and the production of new activity patterns in response to them. Chaos theory approaches provide an answer: the presence of a chaotic well, a high-level chaotic state, available to generate new activity patterns from recombination of the old. Chaotic mechanisms such as this enable neural networks to learn new behaviours quickly enough for human survival; at the moment neural network learning is so slow creatures working on that principle would have failed Nature's test almost as soon as they evolved. Too, it seems clear that the well-worn term "module" is no longer a useful one for such dynamic neural systems: accordingly, the term DYNADS, **dynamic neural devices**, may more accurately express their true nature.

Very recently (1991), Christopher Langton, a computer scientist at the Los Alamos

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434 Kaas, J., The Organisation of Neocortex in Mammals: Implications for theories of Brain formation, **Annual Review of Psychology**, 38, pp. 129-151, 1987.

435 Sacks, O., Neurology and the Soul, **The New York Review**, 22, pp. 44-50, November, 1990.

National Laboratory, U.S.A., proposed a similar survival-enhancing use for chaos in neural networks: he relates network behaviour to the phases of matter, with ordered networks as solid, chaotic networks as gas, and networks in an intermediate state as liquid. At the phase transition on the edge of chaos small and large islands would exist, perturbed by minimal influences, communicating with each other or, rather, being influenced according to power law distribution; nearby sites would communicate frequently via frequent small changes, while distant sites would communicate via infrequent large changes. Langton claims that networks so ordered (or disordered) would be capable of complex computations. Such networks, poised in the liquid transition state, may have optimum chances of evolving, being flexible; they have the capacity to adapt rapidly and successfully through the accumulation of useful variations. The systems' homeostatic nature (a characteristic of all living things) would "damp-down" the frequent small mutations, but a few would cause larger cascades of change. Such poised systems would typically adapt to a changing environment gradually; nevertheless, should there be a drastic environmental change, adaptation can occur quickly. Organisms do, indeed, possess these properties.[436]

Christine Skarda and Walter J. Freeman have conducted a great deal of EEG research on the olfactory bulb, and have formed a connectionist model of its function which makes use of chaotic neural activity as the essential ground state for the perceptual apparatus; they specifically oppose the "digital computer" metaphor for the working of the brain.[437] They explain that the state of a dynamic structure is stable if the system returns to that state after perturbation; it is said to be at equilibrium if it is steady and does not oscillate. The equilibrium point towards which such systems return is called an 'attractor'; plotted as trajectories away from the attractor, the energy values resemble a 'basin' with the attractor at its base, and the vertical axis a bifurcation parameter. Skarda and Freeman say:

> The interconnected structures...cannot stay at equilibrium and must enter ceaseless activity, even if they are only connected to each other and not to the rest of the brain....A bifurcation takes place when the system undergoes a major transition in its dynamics, equivalent to, for example, the transition from sleep to waking, or from normal to seizure activity...We say that the control of the system dynamics is shifted from a point attractor to a chaotic attractor. This simply means that the system falls into a condition of restless, but bounded activity.[438]

Dense feedback interactions produce the boundary conditions of the area of neural matter under study, but with these conditioned or made possible by feedback from exterior areas. The vertical height depicted by the phase portraits of the bifurcation basins indicates the amount of energy in the active state; for instance, deep anaesthesia is the point attractor of a shallow basin, which, with greater energy

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[436] cited in Kauffman, S.A., Antichaos and Adaptation, **Scientific American**, pp. 64-70, August, 1991.

[437] Skarda, C.A., and Freeman, W.J., **Behavioural and Brain Sciences**, 10, pp. 161-195, 1987.
[438] p. 165, **Ibid.**

input, widens upwards to the chaotic attractor of epileptic seizure, the top of a deep basin. The degree of interaction in the system is the bifurcation parameter, which relates to input and arousal, governing the abrupt, global jumps from one state to another, analogous to phase transitions in physics, as in the changes from ice to water to steam.

Skarda and Freeman come close to the concept of the dynad with their Nerve Cell Assemblies (NCA):

The linking together of a selected subset of neurones comprising perhaps 1-5% of the total by strengthened excitatory synapses constitutes the formation of a nerve cell assembly (NCA). Thereafter, excitation of any portion of it tends to disseminate into activating the whole of it...We hypothesise that the activation of some of the neurones of a specified NCA selects the basin of the attractor...The key to understanding this switching device lies in an appreciation of the static non linearity that governs the behaviour of neurones in an interactive mass. When left without input, neurones tend to fall below threshold and remain silent. Under maintained excitation they give steady output. Owing to the ionic mechanism of the action potential there is a dynamic range near threshold in which the tendency to form an action potential increases exponentially with depolarisation. Restorative forces released by an action potential serve to limit the rate of firing...[439]

Skarda and Freeman's NCAs, however, are regarded by them as rather like "mould" on the olfactory bulb which is their main concern; nevertheless, they could be discussing neural assemblies of any size in which the same dynamic processes would take place. Indeed, they have found that the visual cortex of a rhesus monkey operates according to the same basic neural dynamics as the olfactory bulb.[440] Learning, they say, consists in the selective strengthening of excitatory connections among the neurones leading to the constitution of an NCA and to the possible bifurcation to a global activity state; memory, activated under stimulus input, produces global activity patterns characteristic of a particular perceptum. They are most clear concerning how inappropriate the computer model for the brain really is:

These are not the types of mechanisms used by digital or analogue computers. No program-specified rule or operation is brought to bear on input...The component neurones generate their own ordered response to stimuli; they are self-organising. There is no central processor, and learning and memory are functions distributed throughout the neural network...the classical computer analogy may be unsuitable to explain the neural bases of behaviour...Rather than viewing brain function...as a rule-driven and controlled system solving problems, completing patterns, and forming hypotheses by manipulating symbols...neural dynamics suggest that the brain should be viewed as a self-organising process of adaptive interaction with the environment.[441]

Skarda and Freeman say that the high-level chaotic states neural systems fall into when stimulated by a novel perceptum are essential to enable the system to avoid all previously learned activity patterns and to produce a new one. The present writer suspects that autistics, who cling so desperately to habit patterns and

[439] pp. 168-169, **Ibid.**

[440] p. 170, **Ibid.**
[441] **Ibid.**

regularity of stimulation and who react so disastrously to anything novel, may lack the general capability to generate new behaviour in new situations; areas of their brains may be so immature on the cellular level that they lack the capacity to achieve high-level chaotic states. The savant may have a limited capability to do so, but only within isolated neural assemblies. Foetal hormones, disease, injury, or hypoxia might have this differential retarding affect. Oliver Sacks has speculated that idiot savant artists, with their "photographic" reproduction from memory of things they have seen, have no capacity to generalise or theorise. Most pathology may then be reinterpreted in terms of disunity and disintegration as diseases of categorisation, isolated bits of memory, perfectly preserved like bees in amber, continually representing themselves to the pathological consciousness, iterated intrusively, like the tics of a Touretter, or the repetitive cries of an autistic.[442] If the neocortex, last to develop both evolutionarily and ontologically, is the brain area most likely to suffer from epigenetic sources of pathology, then it may be that the left hemisphere, specialised for categorisation, is the hemisphere most likely to be affected, together with the forebrain. Reduced reading, writing, and language abilities, lack of adequate emotional control and the inability to plan ahead will all result.

Interestingly, Sacks, too, has formed the opinion that in Chaos Theory we have a possible explanation for the organisation and function of the brain: as long ago as 1969 he had noted the abrupt oscillations of his L-Dopa patients, from catatonia to mania 30 to 100 times each day. The slightest stimuli would set these shifts off, after a critical point in the administration of the L-Dopa, the extremities of reaction tending to increase, as though through positive feedback. Even more interestingly, Sacks compared the L-Dopa response to a calm stream, with a smooth, laminar flow, which when it increased in force and accelerated to a torrent produced innumerable whirlpools and eddies, surging in a non-linear space. His theorising was curiously prescient: as he points out, no-one was thinking in terms of chaos in the 1960's, or at least very few mathematicians. The concept was not known in the general scientific community.

In 1990, Sacks worked with a colleague, Ralph Siegal, plotting one particular patient's physiological state against its rate of change in order to derive a phase-space representation. This is something first discovered by the mathematician, Poincare, and later used by Lorenz to demonstrate the non-linearity of weather; it uses the time dimension of rate of change to provide orbits or trajectories around the value to which the variable being studied returns. When chaos is in the system, the shape described is the "Lorenz Butterfly", and the point to which all trajectories return is called a **strange attractor**. The patient's data was, indeed, chaotic.

Sacks talks of the strange attractor as being the centre of Parkinsonism, a black hole around which the patient orbits but from which he or she can never escape, sometimes emerging for an unpredictable time into normality, but always sliding back down into that heart of darkness. L-Dopa serves to steepen the angle of the orbits.

Other pathologies, such as diabetes, migraine, and epilepsy, where there is an

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[442] Sacks, **Neurology and the Soul**, 1990

unpredictable periodicity of episodes, are likely to be similarly affected by chaos forces, Sacks says, and even gross psychosis has islands of health in a tide of sickness, with, conversely, islands of sickness in the occasional rush of health. He calls these all dynamical disorders. Most interesting suggestion of all by Sacks is that the post-encephalitic patients' delirious imagery of "maps-within-maps-within-maps", ever-enlarging, ever-reiterating patterns, are actually projections of the self-similar, fractal qualities of their own thoughts and perceptions.

He advocates minute observation of the periodicity of behaviours and symptoms in neurological pathologies in order to understand the dynamical systems involved, as the basis for a future "new rationality" of treatment.[443]

Returning to Oliver Sacks' theorising in his **Neurology and the Soul**, if we allow that the associative areas of the left hemisphere and forebrain ought to be where high-level chaotic states most often and most easily may be found, our capacity to meet the unexpected and the novel, adapt, generate new responses, is what marks us out as the most developed living creature on Earth. Primates and other mammals have this ability to a lesser degree; invertebrates do not seem to have the sort of spare neural capacity to generate such states: most often they react with previously learned patterns of behaviour.[444] Skarda and Freeman conclude by saying:

Nervous system dynamics is a self-organised process constrained by the requirement that the system anticipate and incorporate the immediate consequences of its own output within the larger constraints of regulating its well-being and the long-term optimisation of its chances for survival.[445]

In the "Authors' Response" to the Peer Commentary on their target article, Skarda and Freeman amplified on their position vis-a-vis cognitive science:

What emerges from our work...is the conclusion that the concept of "representation" (e.g., symbols, schemata, codes, maps) is unnecessary as the keystone for explaining the brain and behaviour. This is because the dynamics of basins and attractors can suffice to account for behaviour without recourse to mechanisms for symbol storage and invariant retrieval, "teachers" in learning devices, error-correcting feedback, comparators, correlators, associators, and the fine-grain point-to-point topographic connectionism that is required for their effectuation. The nervous system tolerates (indeed thrives on)

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443 Sacks, O., **Awakenings**, Revised Edition, Pan Books, pp. 351-365, 1990.

444 Skarda and Freeman [p. 189, Response] seem to support such speculation with their own: "We suspect that neocortical cell assemblies tend much more strongly to chaotic activity...", and [p. 191] "...attentive cognition...must involve proprioceptive and reafferent information so that successive sensory information samples can be combined with the information about what is done to get them. We also think it unlikely that each modality will be found to have such neural machinery separately, so that it should be sought after the combination of sensory input from all modalities into gestalts. From neurological considerations the most likely site of convergence is the entorhinal cortex...for which the hippocampus may serve as stack register for temporal integration of serial gestalts."

445 p. 173, **Ibid.**

an enormous degree of what can only be called sloppiness in its design, construction, and maintenance...it is a quality that makes the difference in survival between a creature with a brain in the real world and a robot that cannot function outside a controlled environment.[446]

Other EEG studies have looked at brain activity during sleep and found evidence of chaotic dynamics,[447] while others have found traces of Chaos when studying records taken from epileptics, looking at the processes of image formation, associative memory, motor cortex processing, the development of motor programs in infants, and other cerebral activities.[448]

Popper's comparison of the brain to a laser was mentioned earlier in order to understand more clearly the global changes which take place in development and cognition; Albano, *et al* (1986) have theorised similarly: at low laser pump levels there is a random emission of light wave tracks from the individual atoms of the laser inert gas; as the pump level increases, thresholds are reached, critical **phase-shifts**, which bring about the emission of coherent light, then, after another phase-shift, both big and small pulses are regularly fired but in a truly chaotic fashion. In this way, without altering the nature of the materials used but merely by increasing the energy throughput, qualitatively different modes of operation are attained.[449] In the brain similar qualitative changes may be those between sleeping and waking, between inattention (shown by the dominance of alpha waves in EEGs) and attention, between normal brain function and an orgasm or epileptic seizure. At the critical thresholds, small perturbations can cause the whole system to phase-shift from one pattern of activity to another. A small noise may wake someone, a slight alteration in the almost unperceived environment can catch one's temporarily unfocused attention, a small additional stimulus may tip an excited individual over into orgasm, while something as little as the flicker of sunlight through trees passed while in a car or a train may precipitate an individual into an ictal episode.

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[446] p. 184, Response, **Ibid.**

[447] Babloyantz, A., Evidence of Chaotic Dynamics of Brain Activity During the Sleep Cycle, in **Dimensions and Entropies in Chaotic Systems: Quantification of Complex Behaviour**, G. Meyer-Kress {ed.}, Springer, U.S.A., 1986, and Mayer-Kress, G., and Holzfuss, J., Analysis of the Human Electroencephalogram with Methods from Non-linear Dynamics, in **Temporal Disorder and Human Oscillatory Systems**, ed. L. Rensing, U. Van der Heiden, and M.C. Mackey, Springer, U.S.A., 1987.

[448] Kaczmarek, L.K., and Babloyantz, A., Spatiotemporal patterns in epileptic seizures, **Biological Cybernetics**, 26, p. 199, 1977; Freeman, W.J., Dynamics of Image Formation by Nerve Cell Assemblies, in **Synergetics of the Brain**, {ed.} E. Basar, H. Flohr, and A. Mandell, Springer-Verlag, 1983; Kohonen, T., **Self-organisation and associative memory**, Springer-Verlag, 1984; Rapp, P.E., Zimmerman, I.D., Albano, A.M., Deguzman, G.C., and Greenbaum, N.N., Dynamics of spontaneous neural activity in the simian motor cortex, **Physics Letters**, 110A, p. 335, 1985; Kugler, P.N., A Morphological Perspective on the Origin and Evolution of Movement Patterns, in **Motor Development in Children: Aspects of Co-ordination and Control**, ed. M.G. Wade and H.T.A. Whiting, Martinus Nijhoff: Dordrecht/Boston/Lancaster, pp. 459-525, 1986.

[449] Albano, A.M., Abraham, N.B., *et al*, Lasers and Brains: Complex Systems with Low-dimensional Attractors, in **Dimensions and Entropies in Chaotic Systems,** ed. Mayer-Kress, pp. 231-240, Springer, 1986.

The epitome of minute causes is the dropping of a grain of sand which precipitates a landslide; Per Bak and Kan Chen (1991) have been studying just that, conducting experiments which involve the steady accretion of grains of sand into a pile, down the sides of which slide larger or smaller landslides, begun by the fall of one grain of sand too many. This models their theory that a minor event may start a chain reaction which may affect any number of elements in the system, the mechanism which leads to minor events being the same one which leads to major ones. Such "composite" systems never reach equilibrium, but rather move constantly from one metastable state to the next, each grain of sand element in the system moving and shifting dynamically in self-organised criticality. The authors view fractals as "snapshots" of self-organised critical processes, as **power laws** which describe, among other things, the distribution of vortices in turbulent fluids and the distribution of such sandslides, both large and small. These power laws say that the number of items within, for example, a sphere of radius **r** is proportional to **r** to the power of some constant **D** (which is another way of describing fractals). In a truly chaotic system, the exponential growth of uncertainty prevents prediction; however, with self-organised criticality the chaos is **weak**, and so longer term predictions of behaviour may be made. Per Bak and Kan Chen view fractal shapes as the **spatial** signature of chaos, the "snap-shot", but draw our attention to what is known as **flicker noise**,(or 1/f noise) which they say is the temporal call-sign of chaos: traffic on a busy road exhibits flicker noise, a particular irregular pulse, as a result of the stop-go "avalanches" which propagate through such traffic. If the flow was graphed versus time, there would be seen a very erratic signal, one which has features of all durations, and which suggests that the dynamics of the system are strongly influenced by past events. The opposite would be white noise, which is random, and suggests no relationship with past events. Flicker noise may be found in the sun's activity, galactic light, the current through a resistor, and, of course, the flow of water through a river. It is one of the great mysteries of modern physics, but the authors suggest that it may represent the superimposition of signals of all sizes and durations, the sort of signals produced when a dynamic system in a critical state produces chain reactions of all sizes and durations. All this has obvious relevance to brain organisation and characteristics: if EEGs display flicker noise and neurones show fractal self-similarity, who can doubt that our minds and brains are triggered into action and thought by the merest dropping of a sand-grain decision or sensation?[450] Many other authors have theorised similarly: Nicolis (1986),[451] Jon Kaas (1987),[452] Charles von der Malsburg (1983),[453] Singer (1983),[454] and Molenaar

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[450] Bak, P. and Chen, K., Self-Organised Criticality, **Scientific American**, January, 1991.

[451] Nicolis, J.S., **Dynamics of Hierarchical Systems: an Evolutionary Approach**, Springer-Verlag, U.S.A., 1986.

[452] Kaas, J., The Organisation of Neocortex in Mammals: Implications for Theories of Brain Function, **Annual Review of Psychology**, 38, pp. 129-151, 1987.

[453] von der Malsburg, C., Modelling Self-Organisation and Performance of Neural Nets: How are Nervous Structures Organised?, in **Synergetics of the Brain**, Basar *et al* , Springer, 1983.

[454] Singer, W., Neuronal Activity as a Shaping Factor in the Self-Organisation of Neurone Assemblies, in Basar *et al*, **Synergetics of the Brain**, Springer, 1983.

and Oppenheimer (1985).[455] All seem to be from the continent of Europe or from the U.S.A.; so far no-one seems to be following this theoretical line in the UK.

Skarda and Freeman (1990), in the continuing commentary on their earlier target article, attack the old way of looking at brain functions, especially in perception:

Our view is that neural dynamics in perceptual processing is most accurately modelled by invoking a complex cluster or hierarchy of chaotic states. Because chaotic dynamic activity is extremely complex, taking seriously its role in the brain frees the view that what the brain does when we perceive something is to ingest, store, and recall an internalised correlate of the input. In the light of our recent findings, this representationalist view of brain function appears outdated because it involves concepts that predate the discovery of chaotic dynamics and it misleads by creating spurious problems.[456]

Much of cognitive science is still predicated on the assumptions of representationality. Freeman (1991) expands somewhat on his theories: he says that the controlled chaos of the brain "...may be the chief property that makes the brain different from an artificial-intelligence machine." He goes on:

One profound advantage chaos may confer on the brain is that chaotic systems continually produce novel activity patterns. We propose that such patterns are crucial to the development of nerve cell assemblies that differ from established assemblies. More generally, the ability to create activity patterns may underlie the brain's ability to generate insight and the "trials" of trial-and-error problem solving.....we and other investigators have documented gamma bursts across large cortical regions involved in recognising visual images. As in the olfactory system, familiar visual stimuli are associated with specific amplitude maps of common carrier waves. I predict that when people examine drawings in which foreground and background are ambiguous, so that perception alternates between two images, the amplitude maps will be found to alternate as well....an act of perception is not the copying of an incoming stimulus. It is a step in a trajectory by which brains grow, reorganise themselves and reach into their environment to change it to their own advantage.[457]

Gray and Singer (1989) have shown that widely separated columns of cells in the visual cortex of cats oscillate in synchrony in response to some objects, but show no synchronous oscillation if the stimuli are unrelated. The perception of objects, therefore, may depend on the co-operative interaction of many neuronal groups in a coherent temporal pattern.[458] Perhaps this gives some clue to the way in which different neural areas, sometimes quite widely separated, may be said to be part of one module or dynad. In the presence of stimuli recognised as belonging to

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[455] Molenaar, P., and Oppenheimer, L., Dynamic Models of Development and the Mechanistic-Organismic Controversy, **New Ideas in Psychology**, Vol. 3, No. 3, pp. 233-242, 1985.
[456] Freeman, W.J., and Skarda, C.A., Chaotic Dynamics versus representationalism, Authors' Response, Continuing Commentary on How brains make chaos in order to make sense of the world, **Behavioural and Brain Sciences**, 13 {1}, pp. 167-168, 1990.

[457] Freeman, W. J., The Physiology of Perception, **Scientific American**, February, 1991.
[458] Gray, C.M., and Singer, W., Stimulus-specific neuronal oscillations in orientation columns in cat visual cortex, **Proceedings of the National Academy of Science**, Vol. 86, pp. 1698-1702, March, 1989 {cited in Sacks, O., Neurology and the Soul, **The New York Review**, pp. 44-50, November 22cnd., 1990}.

a particular sort, the different neural areas would be triggered into concerted action to process them.

Box and arrow models are obviously hopelessly inadequate to describe the actual nature of human cognitive processes; like the Ptolemaic model of the Universe abandoned when Copernicus and Galileo proved that the Earth moved around the Sun, such schematic, computer hardware-based conceptions are always going to be subject to constant addition and alteration, due to their inability to represent the dynamic nature of cognitive organisation.

PDP (Parallel Distributed Processing) models are better, but still not up to the job; they would probably fit the old holistic model of brain organisation of Lashley, but have no way of explaining how neural networks can be adaptive and creative in the face of novel input, nor how they maintain differing levels of consciousness. For instance, PDP theories offer no explanation for the lack of knowledge of most humans of their autonomic system's workings: why are we all unable to consciously experience (and control) the functioning of **all** our neurophysiological mechanisms? Adopting a PDP approach would provide no barriers to conscious awareness within the nervous system. The implication of PDP theories is that we should all be Indian fakirs, capable of monitoring our low-level perceptual mechanisms, our heart-rate, general metabolism, and consequently have almost perfect bio-feedback capabilities. Obviously, this is not the case.

Neuropsychology's difficulty with the causal gap between neurophysiology and behaviour can be bridged only by accepting that there is a cohesive and organising force inherent in the brain and deriving directly from its structure which produces aggregates of neural matter capable of initiating behaviour. The fond memories of past attempts at precise localisation of function in the brain must be forgotten, given the evasive, shifting, eminently pragmatic nature of **dynads**: they take what they need in the brain in order to perform what has to be done at any one time. As each brain is somewhat different from the other, and therefore no patient will ever conform to any so-called "classic" case (producing exactly the same symptoms in the syndrome), neuropsychology's case study method can never be used to generalise in any meaningful or useful way. The reasons for each brain being somewhat different from the other are much more understandable from the perspective of Chaos theory, given the sensitivity of such systems to initial conditions.

Edelman (1987) has theorised along similar lines, regarding the existence of anatomical variability in the nervous system as evidence for genetic indeterminism. He states that no two cells within a given structure exhibit an arbour with precisely the same shape, and that no two brains exhibit an identical anatomy, noting that cortical sensory maps, as mapped electrophysiologically, show tremendous variability between individuals. Of course, this by itself does not tell us whether the variability is due to genetic or epigenetic causes. Changeux and Danchin (1976) have argued similarly that the genome cannot contain sufficient information to specify fully all neural connectivity,[459] and Grobstein (1988) more recently cited a great deal of empirical evidence to further support this position.[460] Edelman proposes that Darwinian evolutionary selectivity decides which neural connections and groups succeed or fail, through use and competition, thus aiding adaptation of perceptions and behaviours to the environment in the most favourable way for survival of the individual. He theorises that this bottom-up process of selectivity, governed by small-scale anatomical variability in the nervous system, sensory input from the environment, and rules which order the modification of synaptic strengths with activation, arrives at adaptive function by competitive processes of neuronal group selection through the operation of the synaptic efficiency rules. These rules have no guiding intelligence behind them, no "homunculus", and so they will give rise to what are termed "Non-instructed neural networks". Most theorists from cognitive science and AI refrain from trying to answer the question of how their thinking machines get programmed in the first place-it is usually assumed that the clever algorithms are in place from the start and the necessity for human programmers is ignored; neural network research in recent years seems to be bogged down, and is no further forward than when Edelman was writing.[461] Gray and Singer (1989) quite specifically point out that their findings (quoted above) lend support to Edelman's theories.

Lashley's ideas have been revived by Neil O'Connor, in his recent summation of many years as a research psychologist investigating intelligence, and the possibility of it having a modular as opposed to a unitary nature.[462] O'Connor quotes Fodor as saying that there is no possibility of a science of central cognitive processes, or of localising logic or inference in the brain. He goes on to solve Fodor's problem by postulating a resource of brain neurones, unspecified in character and capable of reflecting changing external relations; these are utilised according to demand and their availability or efficiency. They are taken up by the primary mental abilities or put down according to the task requirements, with fixed specialisation not required. It is this resource which registers as "g" or intelligence. Judgement, comparison, abstraction are so variable as cognitive processes that it makes much more sense for them to be the function of unspecialised and therefore variable neurones; with reference to Skarda and Freeman's work, the required "sloppiness" may be provided by Dr O'Connor's concept of spare neocortical capacity.

O'Connor refers back to Lashley, and his "...non-specialised dynamic function of the tissue as a whole..." (1929), who said that:

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459 Changeux, J.P., and Danchin A., Selective stabilisation of developing synapses as a mechanism for the specification of neuronal networks, **Nature**, 267, pp. 705711, 1976.
460 Grobstein, P., On beyond neural specificity: Problems in going from cells to networks and from networks to behaviour, in P.G. Shinkman {ed.}, **Advances in neural and behavioural development**, Vol. 3, New York: Albex, pp. 1-58, 1988.

461 Edelman, G.M., **Neural Darwinism: The theory of neuronal group selection**, New York: Basic Books, 1987.
462 O'Connor, N., Intelligence, Handicaps and Talents, **The Mental Retardation and Learning Disability Bulletin**, 15, 2, pp. 4156, 1987.

The mechanisms of integration are to be sought in the dynamic relations among the parts of the nervous system rather than in details of structural differentiation.[463] O'Connor concludes that cognitive operations are a dynamic neurological response to patterns in the external world, mediated through modular sources but based on dynamic neuronal patterns.[464] Judgement, decision, comparison, and abstraction are operations dependent on the dynamic function of non-specialised cortical areas, and in themselves form what is usually known as intelligence. Everything else, the skills or capabilities, are therefore not "g". The reason why all cognitive processes intercorrelate is that tests are measuring something held in common by the modules.[465] Inferential operations based in areas of undifferentiated cortex measure alike, correlate, because similar simple and logical processes are being measured. The present writer, however, has doubts concerning how "simple and logical" these processes truly are: might not "g" be a measure of the extent of high-level chaotic activity in the brain, the capacity of that brain to respond to novel stimuli with novel responses?

O'Connor goes on to show that intact and appropriate modules are specialised for different fashions of encoding input. Attempts to use inappropriate modules may result in differing solutions to problems, or perhaps the wrong answer completely. The hearing person may produce one solution to a particular problem, while a deaf person may produce another, the blind opting for one solution and the sighted for a different one. He states that low IQ does not prevent categorisation or the perception of relations and correlates. Subnormals show in some tests less marked signs of intellectual deficiency than signs of specific modular deficits, especially in auditory verbal function.[466] For example, savants show acute awareness of the rules that govern the phenomena in which they are so narrowly interested, and within those narrow limits they utilise considerable reasoning, inference, or intelligence, and often remarkable memory. If the non specialised neurones which form the basis of such cognitive powers are available to come to the aid of that particular modular capability, then it will function more effectively than a module in an individual with fewer resources: it follows that higher measures of IQ will usually point to higher skill levels in savants.

The present writer does not agree with Dr O'Connor on the last point-the literature contains references to very low IQ savants whose "talents" equal those of savants with much higher IQs. Moreover, how may IQ be measured in the savant within the modular skill or across the range of usual IQ subtests? He argues that savants are able to categorise very well within their particular area of skill; this, of course,

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463 p.176, Lashley, K.S., **Brain Mechanisms and Intelligence**, New York, Dover Publication, 1963 {first published 1929, Chicago, University of Chicago Press}, quoted on p.44 of O'Connor.

464 **Ibid.**

465 p. 45, **Ibid.**

466 pp. 47-49, **Ibid.**

does not disagree with the position taken by the present writer.

Shallice (1988) has gone further and postulated a series of non-modular systems that bridge the gap between strict Fodorian encapsulated isolation and Lashley-style equipotentiality; he describes five, of which two, if merged, seem to be somewhat akin to the dynad: 1) "Overlapping Processing Regions", and 2) "Multi-level systems". The first he describes by saying that a process A might require regions X and Z of the cortex, and process B might need regions Y and Z, with the cells in the two regions operating in an equipotential way for each process. X and Y are not parts of two isolable subsystems, since they function as only parts of wholes that overlap. This serves to describe one aspect of dynad organisation. The second system, one concerning multi-level operation, is assumed to be distributed over a large number of neurones, and learns at a speed determined by weightings given to synaptic connections; should this speed of learning be affected by some pathology or immaturity it would still be able to function but less efficiently; should part of it be affected by a lesion or insult, resulting in the loss of some of the neurones, its speed of learning may not be affected, but there may be the loss of part of its usual function. Shallice was using these examples to show that double dissociation, thought by many to be absolute proof of the existence of modules, does not necessarily show that the modules are isolable. Double dissociation is used to describe a situation where two patients show poor performance on complementary tasks, lesion or pathology producing low functioning in the one in a task preserved in the other. In system number two, two sorts of damage to the same set of neurones produces two sorts of impaired performance; strict modular theory would claim that two sets of neurones must be involved.

Both theoretical systems allow O'Connor's "spare neural capacity" to function as he describes it: in the first instance as the shared X and Y, and in the second as the neural capacity which may not only be lesioned or reduced by pathology but surely **augmented** by more powerful demand. Shallice looks only at the afflicted in his arguments, but they must serve to explain the talented as well.[467] Shallice's two theoretical non-modular systems are like 2-dimensional snap-shots from two different angles of the 3-dimensional dynad. Only a phasespace portrait will do.

The Delta Metaphor

In all the above we have mentioned sand piles and lasers, spoken of bifurcations and phase portraits, self-similarity and fractals, the Mandelbrot Set and fig trees, used them to provide a rationale for modular theory and devised a new term, dynads, to describe modules produced using chaotic self-organisation and non-linear dynamics. As yet, however, it may well seem that clarity escapes us, and all that chaos theory has done is produce true chaos and confusion. The restless changeability and fluidity of neural structures and functioning under this conception may not have been fully conveyed, either. Another comparison which

[467] Shallice, T., **From Neuropsychology to Mental Structure**, Cambridge/New York: Cambridge University Press, pp. 250-253, 1988.

has recurred in the above account is with water; this seems an ideal metaphorical medium, as it demonstrates in reality some aspects of chaos; it may serve to clarify the necessarily complex ideas used so far. A simple hydrogeomorphic (water/earth/form) metaphor for dynads is to see them as the rivulets in a muddy delta of a big river, moving towards the sea: when the rain fall in the mountains is high, the water level rises and the rivulets run more strongly, higher, carving a deeper channel for themselves, sometimes overflowing and meandering across the mud, briefly linking with others, incorporating more areas into themselves, achieving greater organisation. So the dynads may begin with a certain basic prewired or inherited "channel" in the structures of the brain, through which nerve impulses flow; should some dynad channel get blocked or gradually "silt up", through lesions or after disuse, then another dynad may deepen and enlarge, grow greater complexity and capacity through use. If neural energy corresponds to the water, the delta substance corresponds to neural matter, modelled and shaped by the water but channelling and constraining that which shapes it.

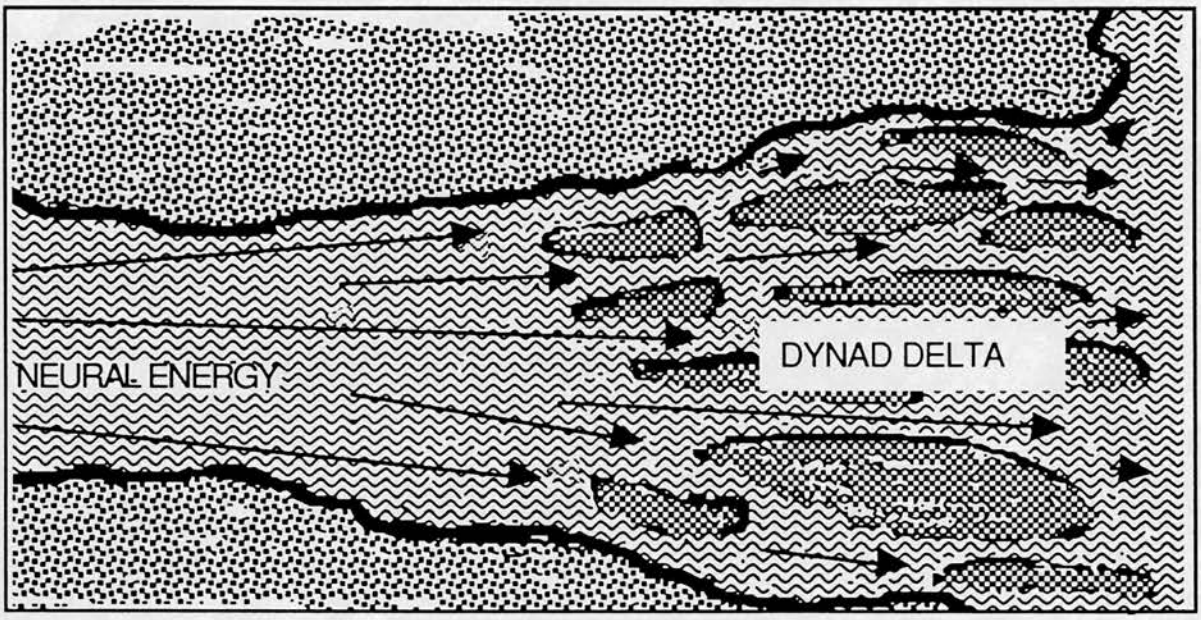

FIGURE FORTY-FOUR: THE NEURAL DELTA

Other brain areas may from time to time become included in the particular dynad as its boundaries ebb and flow with the strength of neural energy passing through. As higher levels of energy become involved so new bifurcation points are met, new choices between chaos and higher levels of self-organisation are faced. Some may break down into non-deterministic true chaos (or, on the behavioural level, inability to categorise), losing efficiency, as excessive stimulation of a particular dynad is made; others may attain greater efficiency levels. As in the production of water vortices, it is more likely at normal energy levels that a new bifurcation point passed will result in organisation, rather than chaos.

The extreme sensitivity to initial states of non-linear systems such as the human organism suggest that minute differences in foetal development, as well as in hereditary disposition, may ultimately decide the eventual patterns and structures of mind and brain. Thus no exact prediction can be made concerning either the mental or physical peculiarities of any one human. Life experiences will, of course, vastly accentuate such differences, although they will always be bounded by the possibilities inherent in human biology. There is no conflict here with the known universals of human brain morphology or behaviour, the predictability of the development of human beings in general. The delta clay is not wholly malleable: it is constrained by granite bedrock, the genetic codes altered only by the earthquakes of mutation.

It is possible that "shallow" dynads, those through which less neural energy flows, do not involve the higher, conscious levels of the cortex; in this instance, skilled behaviours may be performed without conscious processes. If conscious processes are not involved, "intelligence", the measurement of overall cognitive efficiency of the individual, will be less manifest. It may require a critical level of neural energy flow, a new bifurcation point and further self-organisation, before such dynads become conscious in their use. Savants who pursue their favourite skill with motivation and diligence, perhaps brought about by the encouragement of a parent or interested professional, may increase the energy flow through one dynad sufficiently to involve what functioning associative cortex they may still have. The neural energy which in a "normal" would have been spread between all their averagely organised dynads in the savant may be directed into just one or two and so push them to a higher level of organisation and therefore function than would otherwise be possible. If Skarda and Freeman's "basins" are recalled, they appear in schematic form to resemble cross-sections of the present writer's delta channels: if the delta were to be sliced across its width, a multitude of "basins" would be revealed, their low-level point attractors forming the deepest, most primitive channel states. Greater input and arousal energy builds the walls of the channels, control shifting from the point attractor to a chaotic attractor, each bifurcation bringing more powerful states of activity, a creative and survival-enhancing turbulence.

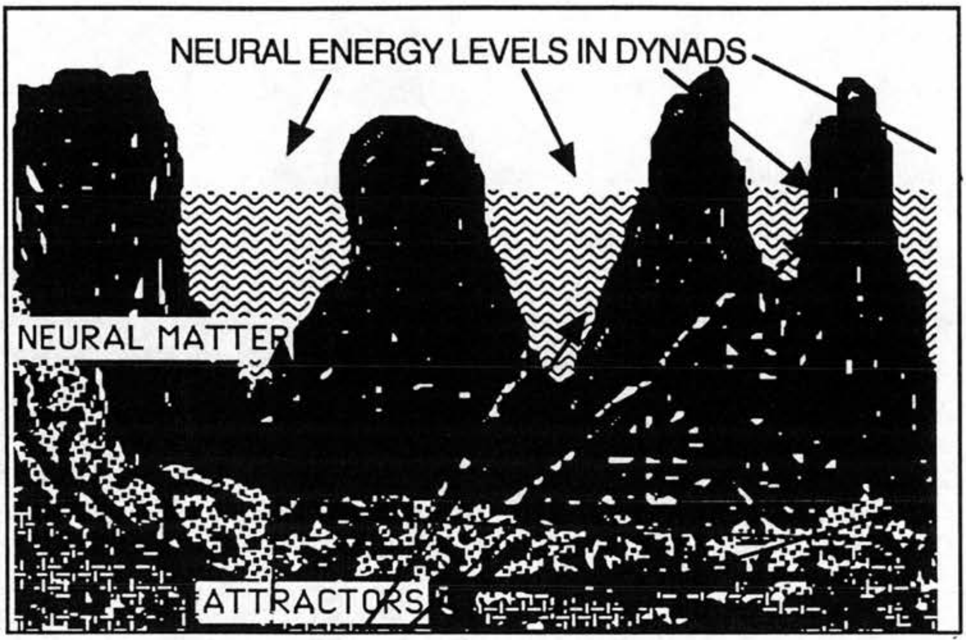

FIGURE FORTY-FIVE: THE DELTA IN CROSS-SECTION [SIMILARITIES MAY BE OBSERVED WITH WADDINGTON'S 'CHREODES', 1957[468]]

<u>What The Delta Metaphor May Clarify</u>

Any model must prove itself by being highly explanatory; the following are some of the explanations the "Delta Metaphor" offers for observed behaviours.

1) *ACQUIRED SKILLS* ---------------- This theory provides an explanation for the transformation of initially conscious skills, such as riding a bicycle or driving a car, into unconscious skills: once the high levels of neural energy required in the first place to amalgamate motor skills and conscious judgements into one new system are no longer required, the system may be subsumed into a "shallow" dynad, a network without conscious elements. The "shallow" dynad may aggregate around a pre-wired capacity for balance, co-ordination, kinaesthetic sense, and/or spatial awareness in the cases used as examples above, and neural energy flow will drop below the critical level previously required to maintain organisation. Attempts to re-introduce consciousness, or to try to "think how I do it", will only disturb and disorganise the dynad, leading to inefficiency and slowness. This is a survival mechanism, allowing conscious capacity to be spared from constant monitoring of motor skills to be utilised in responding to swift environmental changes. It follows that there will always be a steady drift of all skills, or any often repeated behaviour, toward automaticity.

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468 Waddington, C.H., **The Strategy of the genes**, Allen and Unwin: London, 1957

2) ***DEATH OF THE HOMUNCULUS*** ----------------- Like Gardner, like Skarda and Freeman, like Edelman, the present writer dislikes the concept of a central executive, a homunculus who presides over the dynads and directs them. They may overlap as they ebb and flow, sharing neural structures from time to time, but they are all fed by the same motivational, emotional neural "river" source, the producer of energy, the lower brain and the hormone levels, emotions, and desires of the body. Dynads are oriented toward the common goal of survival behaviour, the "sea" beyond the "delta". Because they are self-organised by their nature as non-equilibrium dynamic structures there is no need for a central executive to control them; given a common nature and motivation and a common objective, there seems little need for any homunculus, and so a possible infinite regression of homunculi-within-homunculi is avoided. Such characteristics as common sense, wisdom or any other generalised "horizontal" ability may be seen as emergent properties of close co-operation between dynads in a strongly organised individual in whom the motivational, emotional, and hormonal energy levels are very high. Where this view conflicts with O'Connor's theory of the utilisation of undifferentiated neural material by modules is in the postulate that synergetic processes provide the means whereby aggregation, organisation, and integration could take place, together with the way in which the aggregated entities could co-ordinate as part of a larger whole. As it seems likely that modules share neural matter to a greater and lesser degree on demand, limited by overall energy level, their co-operation is inevitable in the healthy individual. Theirs is a "Coronation Street" society, where resources are shared, creating commonality and unity.

3) ***MEMORY***------------- Memory, as befits its elusivity for present day psychologists, is a capacity shared by all dynads but centred on none. There is no "Memory Dynad". The dynad operating at a higher level of organisation would probably demand more neural memory area, expanding sufficiently to fulfil its needs. Penfield's[469] research into the electrical stimulation of memory, at first hopeful for localisation of function enthusiasts, later proved disappointing for them when it was found that no two people stored the same sort of memories at exactly the same area of the brain. This is what one would expect to find if dynads appropriated specific areas of general memory capacity but organised it in slightly differing ways in each individual. Naturally the organic structure of the brain provides the boundaries within which the modules vary. Marshall[470] briefly cites research which supports this position:

> There are distinct sensory stores for vision ("iconic") and audition ("echoic"); there is an articulated loop implicated in some "short-term memory" tasks and a system of "visual" traces implicated in tasks that cannot be verbally mediated; long-term memory for linguistic material is functionally (and anatomically) distinct from visual or spatial long-term memory...[471]

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[469] Penfield, W., and Roberts, L., **Speech and Brain Mechanisms**, New York, Atheneum, 1966.

[470] Marshall, Multiple Perspectives on modularity, pp. 226-227.

[471] **Ibid**, p. 226.

It seems that dynads have neural memory stores which are both within their individual systems and shared by them; such co-operation ensures that memory stores may cross-reference, allowing us to recall, side-by-side, smells and tastes and sights from the same perceived event. For the savant, the greater flow of neural energy flowing through special skill modules perhaps ensures a greater specific memory, exceptional recall solely within specific areas of ability, within specific sensory modalities, such as vision in the artistic savant. This seems to be the case with all the varieties of savant. Over stimulation of the hippocampus, for example an area of the brain important for memory, [and the area speculated by Skarda and Freeman to be responsible for "gestalt stacking"] results in hypersensitivity, structural changes in dendritic spines and increased numbers of synapses with other cells, even if the stimuli is infrequent or of less than a second in duration.[472] Lynch (1985) has postulated a calcium mechanism for memory storage;[473] where calcium is pumped out of the dendrite to an exceptional degree as a response to over stimulation, hypersensitivity will result. In the neural matter within a specific spared module of the savant this could well result in unusual or prodigious memory. Visual memory skills for artistic savants and for the visual calculators may reside in the visual-association cortex; auditory calculators may have memory hyperacuity in the posterior left temporal lobe.[474] The theories of Lynch[475] stimulate speculation concerning possible deviant calcium mechanisms in autistic savants: it has often been observed that such individuals have deformed or rotten teeth, which usually have to be removed; in addition, they quite often suffer from skeletal defects, such as scoliosis, which are found to a lesser degree in relatives as well. Neural crest-derived thymic connective tissues feature in tooth development, and their absence leads to tooth impairment; as has been detailed earlier, the neural crest plays a leading role in the development of the nervous system.[476]

4) *SCHIZOPHRENIA*------------- Should the motivation be strong enough, neural energy flow would be of a level sufficient either to cause mental breakdown or the attainment of more complex networks capable of producing even better survival behaviour. Dynads would be much more likely to work in concert and be closely integrated in conditions of maximum neural energy flow. Perhaps the high ability found in some manics and schizophrenics prior to breakdown represents the condition of maximum co-ordination and co-operation of dynads; cross fertilisation

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472 p.214, Oscar-Berman, M., Superior Memory: Perspective from the Neuropsychology of Memory Disorders, editors L.K. Obler and D. Fein, **The Exceptional Brain: Neuropsychology of Talent and Special Abilities**, New York-London, The Guilford Press, 1988.
473 quoted **Ibid.**
474 p. 215, **Ibid.**
475 Lynch, G., What memories are made of, **The Sciences**, 25, pp 38-43, 1985.
476 p.157, Geschwind, N., and Galaburda, A.M., **Cerebral Lateralisation: Biological Mechanisms, Associations, and Pathology**, Cambridge, Mass., and London: Bradford Book, MIT Press, 1987.

between modalities, seen very often in the "mad genius" in art, would be expected in such individuals, a powerful use of metaphors, and even synaesthesia, as in the artist and musician, Kandinsky, and in Luria's "Mnemonist".[477] Other, less genetically preorganised individuals would show pre-onset enhanced talents to a lesser and unremarkable degree. However, pass another bifurcation point as the neural energy flow increases, and it may be that such an unfortunate will experience dynad disruption, with irrational leakages of images and sounds into consciousness, like a waking dream.[478] The channels of the neural delta flood and join each other, individual stability broken down. Neuropsychological research supports the present theory by suggesting that schizophrenia is always associated with **increased** activity of some neurochemical tracts. Sheild's polygenic threshold theory of the inheritance and manifestation of schizophrenia harmonises with the present view, life experiences having a differential effect on individuals with a genetically greater or lesser predisposition towards schizophrenia. In those cases where stress causes the phenotypical manifestation of such a genotypical potential, the modularities may attempt a phaseshift to a higher level of organisation and fail disastrously, going the other way, simplifying. Relatives of schizophrenics are often highly talented and stable; it may be that in them the self-organisation succeeds. After all, for such an illness as schizophrenia to have survived the weeding-out process of natural selection, it must confer **some** survival-enhancing characteristics through an associated set of skills, in much the same way that sickle cell anaemia trades-off its deleterious effects with the anti-malarial benefits it bestows. Without wishing to claim that every pathological cloud has a silver lining, it does seem that, unless schizophrenia and mania are evolutionarily very new, by now the genes and polygenes responsible for them ought to have been weeded out of the human gene pool by natural selection unless there **were** good reasons for their continued survival. For every sufferer from any full-blown pathology, it follows, there may be relatives whose survival chances are enhanced by possession of the benign phenotypical manifestation of part of the polygene. As it is postulated that a polygene is involved, the distribution of talents versus deficits ought to be that of a normal curve, with the most extreme examples of both tucked away together in the tails of the distribution.

Therefore, some of the darkest clouds of pathology may have a silver lining, but if detected and encouraged, that lining, as in the savant, will be bright indeed.

5) ***HANDICAP***-------------Those in whom genetic misfortune, disuse, lesion or disease have prevented dynads from developing, such as savants, autistics, dyslexics, the mentally handicapped, these may be left with few dynads functioning at the higher, conscious level, and rely much more than normals on the pre-wired

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[477] Luria, A.R., **The Mind of a Mnemonist**, New York, Basic Books, 1968.

[478] Those individuals who, for the purposes of charity or in experiments, have gone for 200 hours+ without sleep have found that hallucinations occur, possibly as a result of the brain's requirement to catch up on its normal quota of PGO spikes, the register on EEG records of the regular stimuli from the lower brain which normally coincide with REM episodes in sleep. While REM time may be lost, PGO spikes are always made up.

unconscious "channels". The right hemisphere language capabilities of "Genie" seem to indicate that disuse and the consequent loss of use of the normal left hemisphere language dynad does not forbid even children well beyond the one- to two-year-old neural abundance period from developing some language.[479] Perhaps the right hemisphere language dynad usually consists of the basic prewired "channel" only. Nevertheless, dynads need not be restricted in all their subsystems to one hemisphere, and certainly not to the cortex alone. Physical evidence of dynadic organisation may not be clear, but clues are fairly easily seen in particular neurotransmitter tracts, nerve fibre connections between functionally differentiated brain structures, and other gross physiological pointers to dynadic organisation of the genetically pre-wired and later developmentally-structured sort. Marshall, when discussing the neural architecture associated with a language module, states that it must be only relatively fixed, as "...it is clearly spread across a number of different cortical and sub-cortical areas of the left hemisphere."[480] He is encouraged by the discovery that the architectonics of the human cortex appear to map onto the speech areas identified by clinical neurology, as in, for example, the temporal magnopyramidal region, where there are specialised pyramids which do not occur elsewhere in the temporal lobe, and which seem to form a crucial part of Wernicke's area.[481] The shifting boundaries of dynads leave physical traces in the structures of the brain which we are able to detect. Goldman-Rakic recently came to the conclusion that in the associative cortices there are parallel distributed networks which share neural structures and "cross-talk" with each other; she said:

> The picture that emerges from the new anatomy is that of a highly integrated but distributed machinery whose resources are allocated to several basic parallel functional systems that bridge all major subdivisions of the cerebrum...If subdivisions of limbic, motor, sensory, and associative cortex exist in developmentally linked and functionally unified networks, as the anatomical, physiological, and behavioural evidence...suggests, it may in the future be more useful to study the cortex in terms of information processing functions and systems rather than traditional but artificially segregated sensory, motor, or limbic components and individual neurones within only one of these components. Furthermore, in light of the detailed knowledge about specific interconnections at the cortical level, it is to be expected that more and more of this information will be used to guide physiological analysis of higher function.[482]

Goldman-Rakic thus supports both O'Connor and the present writer. It has been observed that hyperlexics may have difficulty in organising motor behaviour on the basis of written information, even though it could be read aloud perfectly; such a disability indicates defective visuo-motor association. Such dissociations between skills seems to be further evidence of neural modularity.[483]

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479 Curtiss, S., **Genie: A psycholinguistic study of a modern-day "wildchild"**, New York, Academic Press, 1977.

480 Marshall, Multiple perspectives on modularity, p. 229.

481 **Ibid**, quoting Braak, H., **Architectonics of the Human Telencephalic Cortex**, Berlin, Springer-Verlag, 1980.

482 Goldman-Rakic, P.S., Topography of Cognition: Parallel Distributed Networks in Primate Association Cortex, **Annual Review of Neuroscience**, 11, pp. 137-156, 1988.

483 Lebrun, Y., Van Endert, C., and Szliwowski, H., Trilingual Hyperlexia, pp. 253-264, Obler and

6) ***FINAL BREAKDOWN***---------------On death, the flow of neural energy organising the dynads, deriving from the vigorous body and the limbic system, fades and stops-the networks begin to slide back down the bifurcation points of their various systems, their integrative powers disappearing, the higher cortical areas the first to be lost to each system as consciousness goes. If a dissipative structure exists which is both made up of and integrates the dynads, an emergent self-reflexive macro-system which could be called the conscious Self, that would be first of all to go, until at last there is no consciousness, and the neural structures organised during development around the various pre-wired capacities break away, dissolving back into true chaos.
Senile dementia is the tragedy of a body still vigorous enough to drive an active brain but where for some reason the "channels" of the dynadic system have uniformly "silted-up"; that which relatives once knew as the personality of the sufferer disintegrates, disappearing as the dynads lose their higher levels of organisation through a reduced flow of neural energy.
Supporting such a view is the recent finding that Alzheimer patients' post mortems show deposits of protein clogging the cortex "like dirt".[484]

7) ***DEVELOPMENT***---------------The development of the child may be seen as the reverse of the above process, the growth of the body, its more and more powerful generation of hormonally driven emotions and desires, needs and drives, providing the neural energy required to organise the already partially preorganised brain into the instrument capable of satisfying those desires and drives through behaviour. In this way we are perfect feedback mechanisms: the body provides the energy to allow the brain to organise sufficiently to direct the body to find more sources of energy. Neonates and infants seem to possess sets of behaviours which spontaneously manifest themselves, and thus cannot derive from any simple stimulus drive; probably increased levels of energy activate pre-wired neural capacities regulated by differential rates of myelinisation and the last slow drifts of cell migration (visible to us when a blue-eyed, blond infant gradually darkens through childhood).
Use dictates neuronal pruning in the abundance period, and so behaviour begins to model the rough-cast neural delta. The prewired capacities which manifest spontaneously during development seem likely to have evolved and been carved in the bedrock granite of our DNA codes by natural selection, having been at some point in our evolution self-organised structures which functioned with greater efficiency. Survival always demands greater speed of effective response; therefore all behaviours must tend toward automatisation.
This is, intentionally, well within the Piagetian model; there appears to be no

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Fein, **The Exceptional Brain.**

484 Anon., Innovation at Science '89, **The Sunday Times**, 17th September, 1989.

fundamental conflict between Piagetian "phaseshifts" in development and the self-organisational phaseshifts of non-equilibrium dissipative systems. Indeed, as has been said, such a compatibility serves to answer one of the major criticisms of Piagetian theory, the "impossibility" of simple systems making themselves more complex. Even Piagetians find it difficult to explain exactly how a higher cognitive stage can derive from a lower one. However, the modularisation of Piagetian stage theory is necessary; different dynads clearly achieve differing "micro-stages" or levels of self organisation across the metaphorical delta of mind.

8)*"INTELLIGENCE"*--------------The reason why Spearman and Thurstone had their famous disagreement concerning the primacy of either "g" or Primary Mental Abilities is that Spearman may simply have detected statistically the extent to which dynads co-operate, while Thurstone detected the extent to which they remained isolated. Eventually, they admitted the existence of evidence for both, although foregrounding their favoured element. If dynads continually waver and change in the sort and number of neural structures they incorporate, while maintaining a core of pre-wired structures, and if they sometimes borrow structures from fellow dynads or lose others to dynads which may be competing or co-operating, it is no wonder Guilford could not identify his 120-odd capacities with any certainty or reliability. Nor is it surprising that followers of a general factor of intelligence cannot explain:

1) the existence of surviving abilities in savants;

2) the differential rates of decline with age for verbal and spatial abilities;

3) the genetically controlled loss of only spatial ability in Turner's Syndrome women;

4) the loss of just one capacity (reading skill) in otherwise "bright" dyslexics.

Lateralisation Of Function

As the basic assumption of both Gordon's Cognitive Laterality Battery and the whole thesis is that psychoneural functions are lateralised, that there are two cerebral hemispheres which differ in their specialised roles for the processing of information, something which has not yet been explained by the theory of dynads is how they may be organised differently in the left and right hemispheres in the normal individual. Superficially, the two conceptions do not map onto each other. Nonetheless, there may be no dissonance between the two perspectives: if, as Goldberg and Costa (1981) maintain, the left hemisphere has more areas devoted to sensory- and motor specific function, and has less white, connective matter than the right hemisphere, which seems to have more areas of associative or integrative cortex, the neurophysiological foundations for differences in psychological functioning are clearly present. Regions in the left hemisphere have more interior integration, while regions in the right hemisphere have more integration between each other.[485] Semmes (1968) earlier proposed that mental processes are distributed over larger regions of brain tissue in the right half of the brain than in the left half.[486] Goldberg and Costa go on to say that as a consequence of such anatomical differences the right hemisphere is better able to deal with informational complexity and many modes of representation within one task, while the left is better able to deal with tasks requiring detailed fixation on single, often repetitive ways of representation or processing. The right hemisphere may be more flexible, able to take on tasks of greater complexity of information.

Similarly, Woodward (1988) conceives of the left hemisphere as relying primarily on tight connections between vertical columns of neurones, while right hemisphere processing relies on weaker and longer horizontal connections. It is not that either hemisphere has a monopoly on one or the other type of connection, vertical or horizontal, only that they differ in which sort is most used. What he identifies as "conjunctive encoding", a term from information processing theory, uses separate, definite units of memory or memory trace, connections between cells, to represent all aspects and relationships between items; this highly specific compactly organised system seems to accord well with the actual neuroanatomical structures of the left hemisphere. In opposition to this is "coarse encoding", where each unit is only broadly tuned, properties and features of one overlapping those of another: such overlapping would mean that if one unit were activated, all those overlapping it would activate as well. The efficiency of coarse encoding increases as stimuli features become increasingly variable. Language would not work well under this organisation: so many incoming bits of information which so closely resemble each other, as in speech, would cause the coarse encoding to break down; the conjunctive encoding system would be ideal for that purpose, however, but it is uneconomic with units, using them up very quickly. Fine motor movements are also well-suited to conjunctive processing, as they require similar, often simultaneous, very specific movements. If the right hemisphere is dominated by horizontal connections, and the left by vertical ones then how is this relative dominance achieved?

Woodward speculates that activity within one hemisphere suppresses similar activity in the other, vertical local circuitry always dominating horizontal, distance circuitry when new stimuli are received (please recall Dahlia Zaidel's findings, which support this); unless a hemisphere is specialised for a particular stimulus, the left will always be put into operation first-it is the "default case"; however, transcallosal transference of information takes place when stimuli are specialised for that hemisphere. It always seems to be the "poor relative", wearing the left hemisphere's hand-me-downs. Right hemisphere visual spatial abilities only seem to develop well when there are two intact and healthy hemispheres,

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485 Goldberg, E., and Costa, L.D., Hemispheric differences in the acquisition and use of descriptive systems, **Brain and Language**, 14, 144-173, 1981.
486 Semmes, J., Hemispheric Specialisation: A Possible Clue to Mechanism, **Neuropsychologia**, 6, 11-26, 1968.

while left hemisphere language abilities are able to develop in the right hemisphere (recall "Genie"). In development, says Woodward, it may be that the left hemisphere attains dominance over the right, imposing specialisation through callosal inhibition of vertical circuitry there.[487] Cook (1984) has theorised along similar lines with regard to callosal inhibition: "dog" (to recall an earlier category) may excite the cortical neurones in the left hemisphere which represent it, but would send inhibitory messages to the right hemisphere core concept, while allowing the peripheral dog related neural assemblies there to be excited ("borzoi", "jackal", "dog-lead", "Kennomeat", "walkies", etc.). Perception of an independent, core visual figure may then be a left hemisphere function, while the context and associations for that figure will be the area of competence of the right hemisphere. Right hemisphere damage often reduces the individual's ability to appreciate such context-related aspects of existence as humour and metaphors.[488][489]

Zaidel's findings concerning the apparent processing of metaphors in the left hemisphere do not seem to support the above conclusions; the general consensus over the years that metaphors are right hemisphere processed (Howard Gardner's work on metaphors, especially) seems to outweigh Zaidel's conclusion, however. The surrealist paintings, collections of independent, very different objects placed together on the picture plane display a disparity which perhaps conjunctive processing in the left hemisphere overlays with an imposed relational framework that jars because of its impossibility. Realistic paintings, however, assume that all will be as one, nothing incongruous, features overlapping in a holistic contextualised perception there will be no jarring, no uncomfortable feeling as a dissonance between probability and what is seen in the surreal works makes itself felt. Coarse encoding deals very well with the usual and expected, the concrete and whole; conjunctive encoding takes each pictorial bit of information at a time, the best way to deal with the novel and strange, for which an adequate response has yet to be automatised.

How does all this relate to dynadic organisation? Clearly, if the neurophysiological foundations of the two hemispheres differ in such a way, more white matter in the right, grey matter which is more loosely organised than in the left, where columnar organisations of neural material are used much more, then it may be possible to expect the organisation of psychoneural dynads to differ, as well. It

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[487] Woodward, S.H., An anatomical model of hemispheric asymmetry, **Journal of Clinical and Experimental Neuropsychology**, 10, 68, 1988.

[488] Cook, N.D., Callosal Inhibition: The Key to the Brain Code, **Behavioural Science**, 29, 98-110, 1984.

[489] All of the above research was cited in Chapter 12 of Springer, S.P., and Deutsch, G., **Left Brain, Right Brain**, Third Edition, New York: W.H. Freeman, 1989.

must be remembered that the theory states that dynads may only work constrained by the "clay" of the "delta". The neuroanatomy of the brain imposes the parameters within which they function; if positive feedback encourages a particular type of psychoneural organisation to reinforce itself within two somewhat differing neuroanatomical areas, then two slightly differing styles of organisation can be expected to become much more differentiated over time and with development. Consequently, if the right hemisphere encourages the development of "shallow" dynads, more easily "flooded" and therefore more often communicating and overlapping each other, the easy exchange of images, consistent contexts, holistic perceptions will be centred there; the left hemisphere neural structuring encourages the development of dynads which are deep, able to generate more diversity of response to novel stimuli through the presence within them of chaotic-attractors and chaos wells; these are produced by the inner possession of high numbers of interconnections and consequent elevated levels of feedback. Such dynads do not flood easily, operate with a great measure of independence, and yet tend to function in tightly-knit, highly co-operative groups.

Escaping briefly from the delta metaphor, that of a "Coronation Street" used earlier may be more suitable for right hemisphere functioning, while left hemisphere functioning may be compared to an Army brigade, neatly divided into sub-units, who, for all their proud autonomy, swing into concerted action when the order is given, and may be better able to give a quick response to alarming or unusual events than "civvy street". Extending the metaphor, armies always have civilians to maintain them, while civilians always have soldiers and army posts among them: so the two hemispheres are dominated by but do not wholly consist of one or the other type of dynad.

Not all dynads are the same, it is clear, but they are made different by reason of the neural organisation of which they consist.

Sperry, Searle, And The Intentional Mind

At an earlier point the concept of downward causation was mentioned, the way in which constituent subsystems could be integrated and marshalled by the greater system of which they are parts. The mind/brain problem has been tackled by thinkers such as Sperry;[490] he said:

> Conscious phenomena [are] emergent functional properties of brain processing [which] exert an active control role as causal determinants in shaping the flow patterns of cerebral excitation. Once generated from neural events, the higher order mental patterns and programs have their own subjective qualities

[490] Sperry, R.W., Mental phenomena as causal determinants in brain function, **Consciousness and the Brain**, ed. Gordon Globus, Grover Maxwell, and Irwin Savodnik, Plenum, NY and London, 1976.

and progress, operate and interact by their own causal laws and principles which are different from, and cannot be reduced to those of neurophysiology...The mental forces do not violate, disturb, or intervene in neuronal activities but they do supervene...Multilevel and interlevel causation is emphasised in addition to the one-level sequential causation traditionally dealt with.[491]

John Searle says that in the same way a molecule of water may be forced to go where the dynamics of the river of which it is a part dictate; that molecule has its own properties and dynamics, and yet none of them include the property of wetness or coldness. The molecule of water has its own organisation but must perforce become a part of the larger organisation of vortices and wave patterns in the river, obeying the regularities found in those macro-organisations. Similarly, a neurone functions according to its own regularities, responding to electro-chemical stimuli, but no one neurone can be pulled from the brain and identified as experiencing pain or thirst or a mystic revelation![492] The concept of neural networks/modules/parallel processors to some extent simply breaks up the mind/brain problem into a minds/brains problem; nevertheless, given the nature of self-organisational nonequilibrium systems there seems little need for a central executive to co-ordinate these self-organised dynads, because they, too, must obey the regularities and forces of a higher level self-organised system which might be termed the intentional mind. The whole is built on feedback, because the units of which it is made dictate the limits and nature of the structure, just as **their** co-ordination is dictated by the whole. The implication of this theory is that there is no dualism, no mind separable from brain, no homunculus as a controller and co-ordinator of thoughts and mind structures. It might be possible to make a distinction between consciousness and intentionality, consciousness deriving from the use by dynads of undifferentiated neural units to give Fodor's "horizontal" capacities, while intentionality might derive from the higher-level self-organisation of all the dynads. One may be conscious but lack volition, as in a state of hypnosis, or have volition (of a sort) but lack consciousness, as in sleepwalking or sometimes in a state of *petit mal.* In the former there is awareness but no desire to do anything other than what one is told, while in the latter there is the intention to move and do things, such as drinking a glass of water or preparing a meal or walking along a window ledge or driving the car to work, with absolutely no awareness of doing so.

A further implication of the theory is that it brings about a microcosmic version of Nietszche's "Death of God"; we do not need a Swiss gnome to run our cognitive cuckoo clocks; in the same way we do not need a kindly old man in the sky to run the world. Instead, there appear to be natural laws which organise our neural systems because they are made of the sort of units they are, and because they naturally engage in feedback relationships with each other. It seems intuitively correct for our brains to function strictly in accordance with physical laws to be

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491 Sperry, R., **Science and Moral Priority**, Columbia University Press, New York, p. 92, 1983, quoted in Davies, p.192.

492 Searle, J., **Minds, Brains and Science**, Harvard University Press, p.22, 1985.

found operating everywhere in the Universe, from laser beams to rivers to that self-organising system big enough to swallow several Earths, the Great Red Spot in the atmosphere of Jupiter.

Perhaps the need of cognitive scientists to cling to the concept of the Central Executive derives from a semi-atrophied religious need to believe that Something is in control, somewhere. It is a belief that, if only for reasons of parsimony, ought to follow the once-hallowed belief in the Ether into the dustbin.

Finally, when we die, we do not give up any ghost to wail away to Hades, as Homer used to put it, but rather the waters of thought ebb and subside, leaving the modular delta to turn to dust together with the body which had been both river source and delta substance. As Oliver Sacks puts it:

> One is not an immaterial soul, floating around in a machine. I do not feel alive, psychologically alive, except insofar as a stream of feeling-perceiving, imagining, remembering, reflecting, revising, recategorising runs through me. I am that stream-that stream is me.[493]

Summary

According to the Delta Model of dynads, the brain organises itself thus:

1) Before and after birth for up to two years, the REM dreamsleep of the foetus, neonate, and infant, together with life experiences and the pre-wired predispositions inherited through its genetic line, act together to form proto-dynads in the brain.

Each dynad has its own memory capacity, but shares substance and thus interacts with the others synergistically; it serves to maximise the energy level of the body by the performance of behaviours on an optimum survival basis, which include catering to emotional needs. There is no Higher Authority which orders the dynads what to do next, unless it is an emergent Self, the product of dynadic interaction and self-organisation, but not centred anywhere, and no more a Spirit or Soul than is the collective intentionality of a football crowd.

Development follows Piagetian lines, but need not be unitary, with the dynads allowing differential capacities to emerge; through self organisation via "weak" chaos, the mystery of more complex stages deriving from simpler ones is solved.

Motor skills may be acquired initially consciously, but later become "shallow", with little higher cortex involvement. Conversely, higher cognitive skills may involve greater areas of associative or forebrain cortex over time and with use, although the tendency is always toward automaticity.

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493 Sacks, Neurology of the Soul, p. 49, 1990.

The Delta Model allows a perception of the ways in which dynads both produce the neural organisation of the brain and are circumscribed by their own creations, just as a river delta moulds the alluvial clay and is channelled by it. Excessive energy flow causes "flooding" of the delta, where dynadic self-organisation breaks down into chaos, and there are irrational and synaesthetic memory and sensory exchanges between the overloaded, drowning structures.

Over-stimulation may produce orgasm, ictal episodes, schizophrenia, mania; under stimulation may produce depression, sleep, coma, and, ultimately, death, when insufficient bodily energy allows the slide down the bifurcation points of the fig-tree of the dynamic non-equilibrium system into final break-up. Optimum conditions therefore exist only at the top of an up-turned "U"-shaped curve.

Intelligence is simply the outward measure of the extent to which dynads cooperate. High energy levels of body and mind will produce high intelligence measures, or "brightness", while the low energy levels of the "dull" signal their lack of intelligence. In those autistics or dyslexics with high energy levels, who exhibit broad or narrow cognitive disability, neural damage would seem to have prevented the proper usage of such energy: one or many "channels" are not available in the dynadic delta.

Lateralisation of function may occur through the positive reinforcement of the already present neurophysiological nature of the delta, as though it had bifurcated as a result of some geological difference underlying the clay, predominantly sandstone on one side, predominantly granite on the other, deep dynadic channels on one side, shallow, often linked channels on the other side. Thatcher (1987) found that, using measures of EEG with 577 children, ranging in age from 2 months to early adulthood, the left and right hemispheres developed at different rates and with different postnatal onset times, with the timing of growth spurts overlapping the timing of the major developmental stages described by Piaget. From the age of 3 to 6 years the left hemisphere showed a strong increase in growth, while the right hemisphere, which had been dominant in growth until then, continued to grow but at a much slower rate, some left hemisphere areas attaining 90% of adult development by the age of 5, analogous areas of the right hemisphere not doing so until 9 years.[494] All of this seems to indicate that with the myelination and development of the two types of neural bedrock, so the left hemisphere attains its dominance over the right. It is clearly not coincidental that this corresponds for most children to the beginning of schooling at 3+, some genetic "prewired" predisposition for left hemisphere dominance encouraged and enhanced by its preferential stimulation in the schools of Western culture.

In the generally cognitively deficient, only the savant possesses one or more dynads through which otherwise blocked energy may be usefully channelled. The dyslexic has the reverse problem, where one dynad, that concerned with reading

494 Thatcher, R.W., Walker, R.A., and Guidice, S., Human Cerebral Hemispheres Develop at Different Rates and Ages, **Science**, 236, May, 1987.

skills, has been blocked by poor core structuring during prenatal development, while other channels function well. Albert Galaburda has recently found **ectopias**, or "cortical warts", around the language areas in the left hemispheres of dyslexics, non-functional structures full of stunted neurones which probably act to distort and block lexical processes. These may be the result of faulty pruning during the superabundant neurone period.[495]

The Self is probably an emergent property of dynadic co-operation and their overall self-organisation. A sense of Self may be poor in some of the brain-damaged and severely handicapped, as it appears to be in the autistic, indicating that perhaps, as the damage is often left hemisphere, the Self-concept originates there. What better, where the dynads are so inward-turning? To have a theory of mind about others one must first have a coherent sense of one's own existence. Having a sense of Self produces a sense of Other, which, equally, most such individuals do not have. Some would argue conversely, that it is the sense of Other which produces the sense of Self; however, unless there is consciousness of separateness and individuality the Other cannot be distinguished from the Self, an error which leads to behaviours such as the autistic child's use of the caregiver's hand as an extension of their own in order to open doors or reach high objects.

The Delta Model consists of river, delta, and sea: over the river may be superimposed the shape of the human body, over the delta may be superimposed the head and brain, while the arms and hands reach out into the sea of behaviour. Just like the cycle of evaporation, rainfall, river flow, so the cycle of survival behaviour, optimum body care, and maximum neural energy produces efficient cognitive system functioning. This is reduced by disadvantageous somatic and psychological factors, the manifestation of genetic and epigenetic influences, some of which have been identified in this research:

1) Parental occupation appears to affect their childrens' level of functioning, either through social or genetic effects;

2) Left-handedness in the family appears to increase the chances of lower cognitive and physical functioning;

3) Arts subjects (music and, to a lesser extent, visual art), having asthma in the family, having only one true area of ability, clumsiness, preference for painterly, coloured art-work, having a right-hemisphere cognitive profile as identified by the CLB, persistent child illness, deep-daydreaming, derealisation ('Loss of Reality'), birth in late winter, having light-coloured hair and eyes, and being antisocial all appear to be associated with lower cognitive functioning.

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[495] Galaburda, A., Paper presented at the Rodin Dyslexia Conference, University of North Wales, Bangor, 16th of September, 1989.

Assuredly, it is not beyond the power of human wit to find many more. Depressing though this may be, as Tennyson wrote "...that which we are, we are...". It is a great wonder that we function as well as we do, that our dynadic and general bodily organisation withstands so well the onslaught of so many inimicable entropic forces. Essentially, this thesis has been written from the philosophical position that for all of us, at birth or before, the bottle is half-empty, not half-full; those who would talk about equality of opportunity, of the talented as having been 'given' that little bit extra, still hold the **proto-religious, essentially non-scientific** position that, somehow, Something has been the benefactor for those individuals. Cartesian dualism, that last refuge of the Judeo-Christian soul in science, infects the thinking of those who would hold that position. We are seen as having been given at conception a small flame of Godhood, the Holy Spirit; for some, the Great Souls, artists, writers, thinkers, heroes, even some scientists, the flame burns a little brighter than for the rest of us. Inspiration, in its original meaning the Breath of God, is 'given' to them. This writer utterly rejects that conception, but not to embrace a soul-less reductionism, the 'nothing-but' position that only the brain exists-that is a manifestly fallacious philosophy. Consciousness is a scientific fact, a causal property emergent from neurophysiology but which has no existence independent of the organisation of that neurophysiology. Self-organisation, as described in Chaos theory, may be seen as eliminating the need for the soul felt by some. The healthier and more complete the neurophysiology, the greater the complexity of the feedback connections, the better organised the dynads, the more subtle the level of consciousness, more and more powerful abilities are available, and, therefore (as some would have it) the Greater the Soul. We less complete beings are no less human, for all that; we all have the capacity to excel, using what has been spared from deleterious influences-are we to ignore the salutary lesson of the savant? Shall we show ourselves to lack their humanity and courage in the face of truly fearful disadvantage? That is for now: it may be that human destiny lies in devising the health, environmental, educational, and even genetic engineering measures which will eliminate all those elements which reduce us, so that, in the future, the waters of our rivers and the waters of our minds will run equally pure and free. Perhaps only then will we be able to realise the unimaginable potential which is nearly always there at our conception, the full potential which is glimpsed imperfectly in our Einsteins and Hawkings, our Picassos and Michelangelos, the people we name "genius". Whatever we call them, they still resemble our true potential only as much as the shadows cast on the cave wall in the parable by Plato resembled the brilliant light of reality.

Appendix I QUESTIONNAIRE ON CHARACTERISTICS ASSOCIATED WITH TALENT IN ART AND MATHEMATICS (categories used in the analysis);

Are there any artists, architects, mathematicians, or engineers in your family?

PLEASE GIVE RELATIONSHIP(S)..

What hand are you? ....

What hand do you use to:

hold a hammer.....................................

write...

unscrew a jar or bottle top.......................

throw a ball.....................................

open a box.......................................

catch a ball......................................

Can you cut the finger nails of your right hand with scissors? ....

Are there any left-handers in your family? ....

PLEASE GIVE RELATIONSHIP(S)...

Do you or any of your family have a history of allergies? [hay fever, rashes, blisters, swellings, asthma?] ....

Are you short-sighted? .... [Severely? ....]

Are there any short-sighted individuals in your family? PLEASE GIVE RELATIONSHIP(S)...

Do you have any musical ability? ....

Do you have mathematical ability? ....

Did you spend a lot of time drawing?... [How many hours per day? ....]

Did you find you had to draw on the walls, window condensation, exercise book margins and so on when there were no proper materials available?............. ....

Where did you find your subjects?..

Did you copy them from books, magazines, or photographs?.....................

Did you draw them from real life? ....

Could you draw some subjects from your head?.................................

Since you started, have there been gaps, when you didn't do much [artwork] [mathematics]? ....

Could you say [art] [maths] is the only thing in life you do really well? ....

Were you a clumsy child?...

Were there any other "physical" things you were good at, such as riding a bicycle a special way, juggling, hand balances, or any "party tricks" for which you have become famous amongst your friends? ....

Are you still good at such feats of control and co-ordination? ....

Can you thread a sewing or darning needle first try? ....

Would you say you were skilful with your hands in a craft or assembly sense?...................
[Lego, Airfix kits, wood-carving, home-assembly kitchen units, tapestry, needlework, and so on ....]

Do you prefer colour or black and white work? ....

Did you have an early understanding of perspective? ....

Were you able to make an object or a building look solid, or give the illusion of depth or distance in your drawings?...............................

Do you doodle a lot? Geometrical shapes, "organic" shapes, human shapes, animals? ....

Do you prefer patterns or abstract art to realistic or photographic pictures? ....

Were you often ill as a child? ....

Were you on your own a great deal as a child? ....

If so, because you were ill quite often or because you wanted to be alone?...............

Would you say you were a very lively child? ....

Would you go so far as to say you were hyperactive? ....

Would you say it was only [drawing] [mathematics] which made you sit still? ....

Did you ever live in a world of your own, always daydreaming? ....

Did other people often have difficulty "getting through" to you? ....

Was there a time when you really didn't like other people? [Did you hate anyone being near you?] ....

Do you still feel like that? ....

Do you sometimes feel that life does not make much sense? [Do normal things and events sometimes seem alien, chaotic, and frightening?] ....

Did it seem like that to you as a child? ....

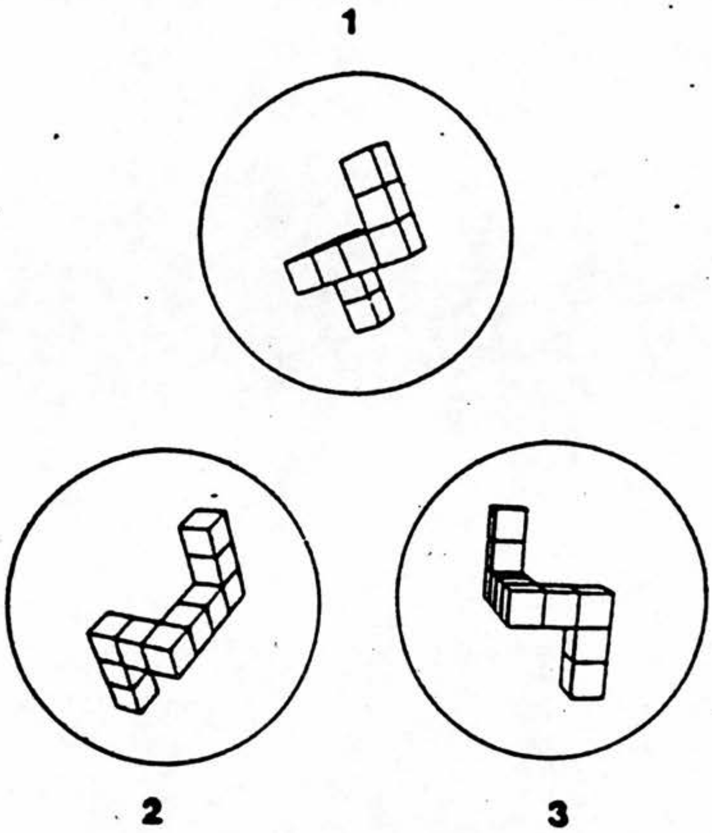
Has anyone mentioned when you first began to speak? If you know, when was it? ....

Were you early or late in learning how to read or write? ....

Has anyone mentioned when you first learned how to walk? If you know, when was it? ....

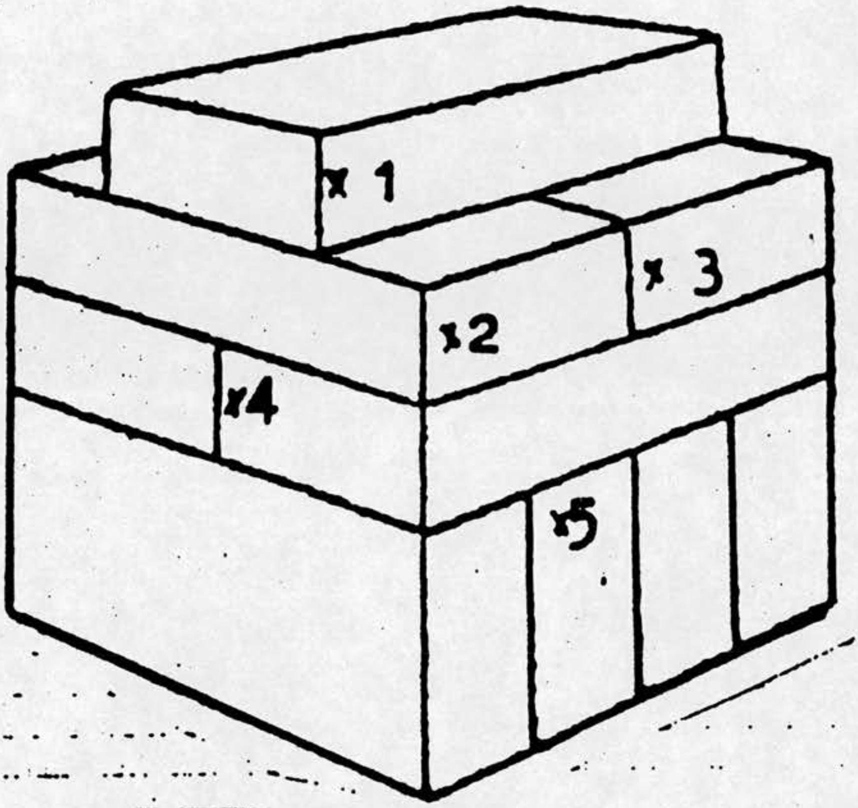
<u>Appendix II ANSWER BLANKS FOR THE CLB AND EXAMPLE STIMULI;</u>

AMPLES OF THE STIMULI USED IN THE VISUAL-SPATIAL/APPOSITIONAL SUB-TESTS OF THE COGNITIVE LATERALITY BATTERY



RIENTATION-3D: THE STIMULUS IS A SLIDE OF THREE, THREE-DIMENSIONAL, S-SHAPED ONSTRUCTIONS OF 10 STACKED CUBES. ALL THREE ARE IDENTICAL BUT ROTATED IN SPACE ROUND A VERTICAL AXIS, EXCEPT THAT ONE OF THE THREE APPEARS AS THE MIRROR IMAGE OF THE HER TWO. (24 SLIDES) THE SUBJECT HAS 15 SECONDS FOR EACH SLIDE.

RM COMPLETION (GESTALT CLOSURE): THE STIMULUS IS A SLIDE CONTAINING SIX INCOMPLETE HOUETTE DRAWINGS OF COMMON OBJECTS OR SCENES. THEY ARE PRESENTED AS WHITE HOUETTES ON A BLUE BACKGROUND. EACH DRAWING IS ENCLOSED IN A RECTANGLE WHICH IS RANGED IN A 2X3 ARRAY ON THE SLIDE. THE TASK IS TO IDENTIFY IN A WORD OR TWO EACH OFTHE AWINGS AND WRITE THE ANSWERS IN SIMILARLY ARRANGED RECTANGLES ON AN ANSWER BLANK. ERE ARE FOUR SLIDES OF SIX ITEMS PER SLIDE, EACH PRESENTED FOR 45 SECONDS.



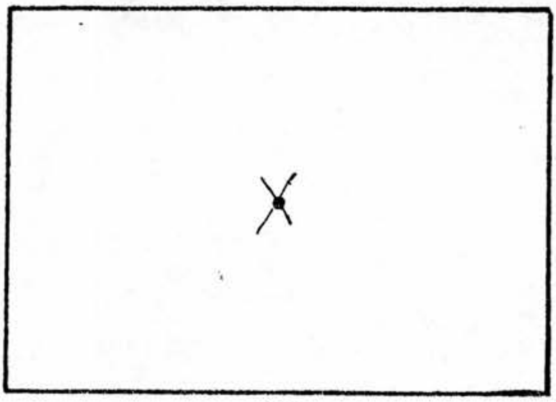
TOUCHING BLOCKS: THE STIMULUS IS A SLIDE OF ONE LARGE CUBE CONSTRUCTION MADE UP OF 8-10 STACKED RECTANGULAR BLOCKS. THE BLOCKS ARE STACKED SO THAT 2 TO 8 BLOCKS MAY BE ADJACENT TO/"TOUCHING" ANY ONE BLOCK. FOR EACH STIMULUS SLIDE, FIVE OF THE RECTANGULAR BLOCKS ARE NUMBERED AND THE SUBJECT IS GIVEN 45 SECONDS TO COUNT THE BLOCKS TOUCHING EACH OF THE NUMBERED BLOCKS. THE SUBJECT RESPONDS BY WRITING THESE AMOUNTS ON A RECORD PAGE. THERE ARE SIX SLIDES FOR A TOTAL OF 30 ITEMS.

THE REMAINING VISUAL-SPATIAL/APPOSITIONAL SUB-TEST IS LOCALIZATION, WHICH HAS AS A STIMULUS SLIDE A BLACK FRAME ON A WHITE BACKGROUND, THE DIMENSIONS OF WHICH BEING NEARLY THAT OF THE SLIDE ITSELF. IN THE CENTER OF THE SLIDE IS A SMALL NUMBER WHICH DESIGNATES THE TRIAL NUMBER. THIS SLIDE REMAINS ON THE SCREEN FOR 3 SECONDS. THE SECOND SLIDE IS THE STIMULUS, CONTAINING THE SAME FRAME BUT WITH A SMALL, BLACK "X" MARKED SOMEWHERE WITHIN IT. THE STIMULUS SLIDE REMAINS ON THE SCREEN FOR 3 SECONDS, FOLLOWED BY A TOTALLY BLACK SLIDE FOR ANOTHER 3 SECONDS. A BLANK FRAME IS PRINTED ON THE ANSWER PAGE WITH THE SAME PROPORTIONAL DIMENSIONS; THE TASK IS TO MARK WITH A PENCIL THE EXACT LOCATION OF THE "X" IN THE FRAME ON THE ANSWER SHEET AS IT IS IN THE FRAME ON THE SCREEN. ON THE ANSWER SHEET, BUT NOT ON THE SLIDE, A DOT IS DRAWN AT FRAME CENTER.

LOCALIZATION TEST

DATE: ______________________

EXAMPLES



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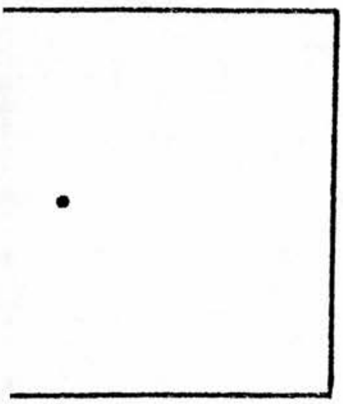

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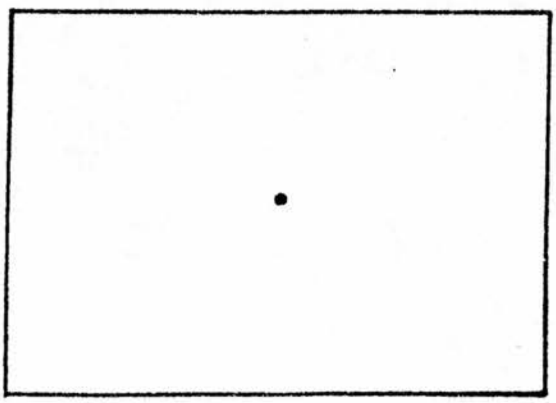
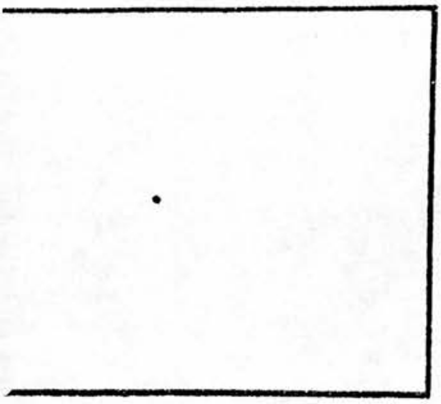


c

TEST

Page 1



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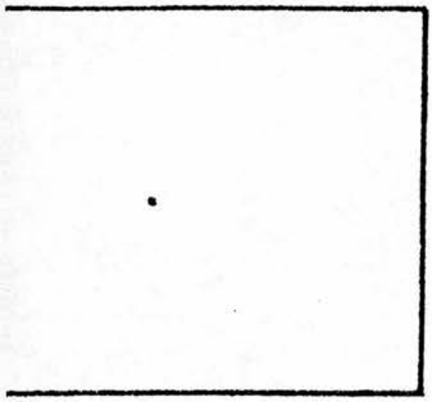

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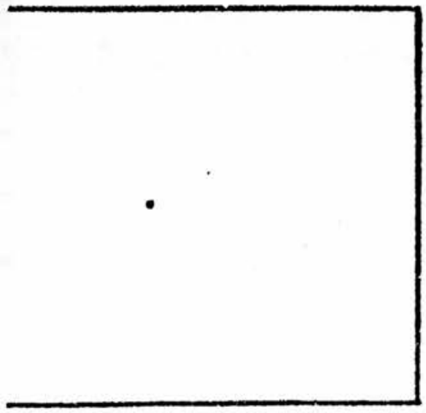

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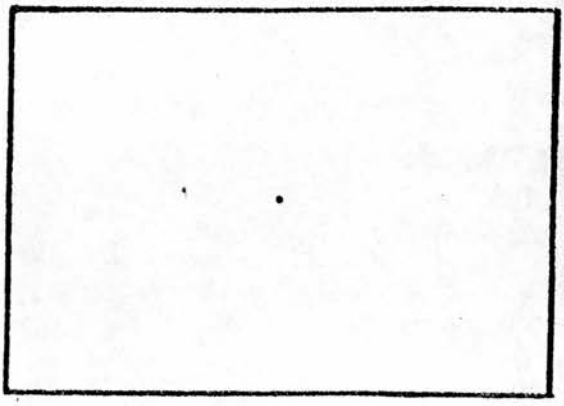

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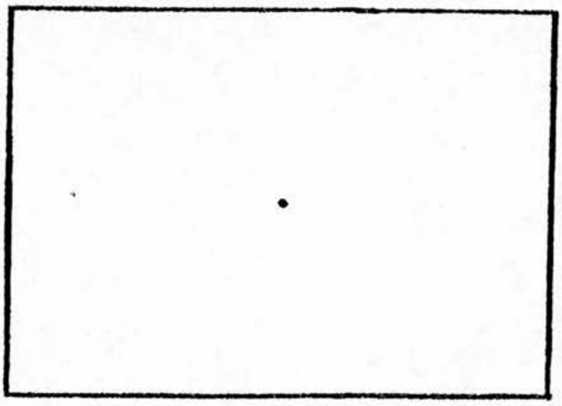

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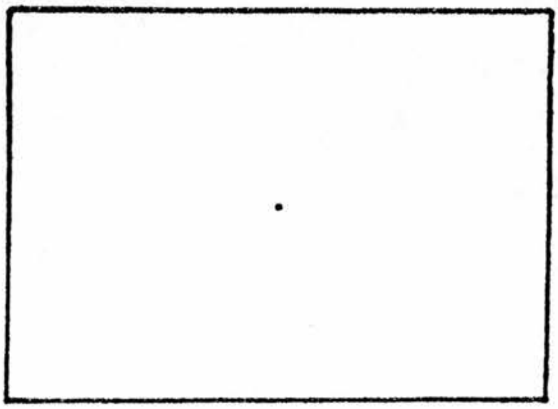


6

TEST
Page 2

7

8

9

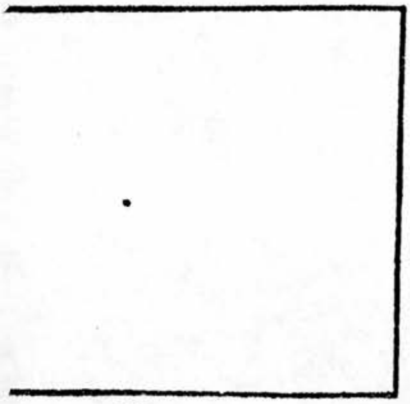
10

11

12

TEST

Page 3



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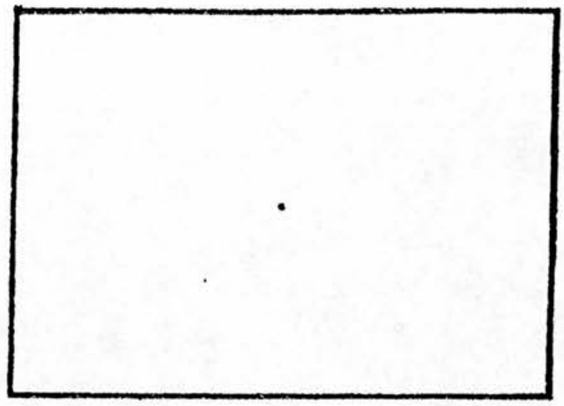

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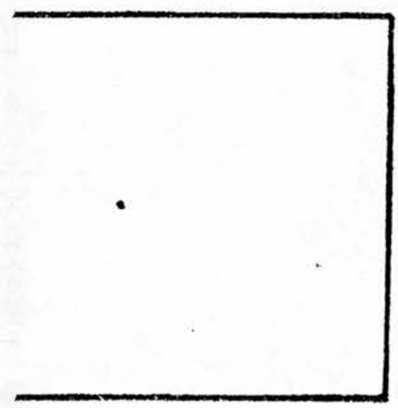

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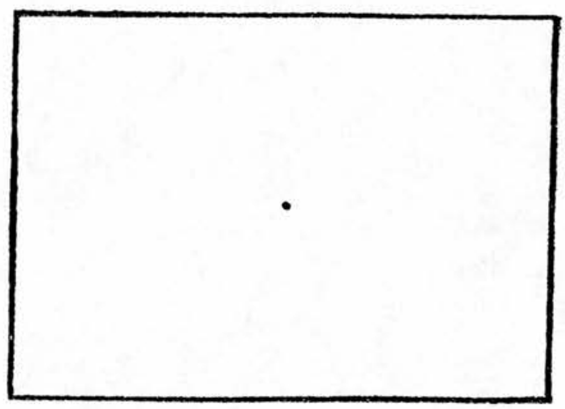

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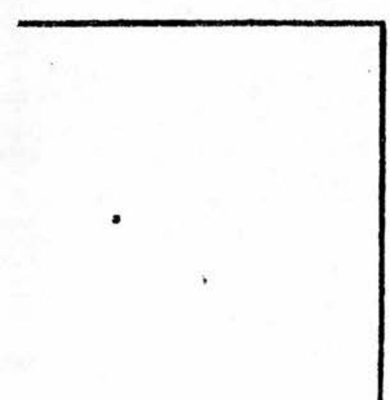

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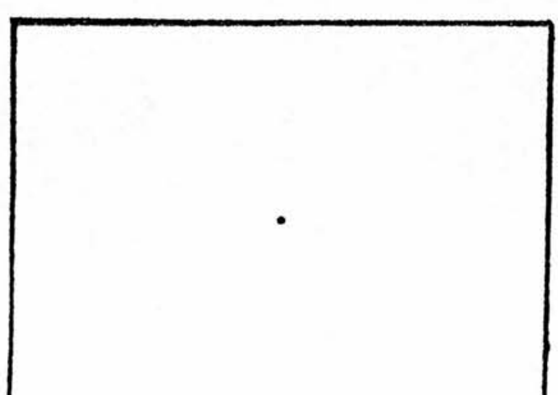

18

TEST

Page 4

19

22

20

23

21

24

ORIENTATION TEST (3-D)

:____________________________ Date:____________________________

____

e: 1 / 2 3		
: 1 / 2 3	9: 1 / 2 3	17: 1 / 2 3
: 1 / 2 3	10: 1 / 2 3	18: 1 / 2 3
: 1 / 2 3	11: 1 / 2 3	19: 1 / 2 3
1 / 2 3	12: 1 / 2 3	20: 1 / 2 3
1 / 2 3	13: 1 / 2 3	21: 1 / 2 3
1 / 2 3	14: 1 / 2 3	22: 1 / 2 3
1 / 2 3	15: 1 / 2 3	23: 1 / 2 3
1 / 2 3	16: 1 / 2 3	24: 1 / 2 3

FORM COMPLETION

Name:______________________________ Date:__________________

Examples:

Man pushing wheelbarrow

A

B

C

1

2.

4.

6.

2

1.

2.

3.

4.

5.

6.

3

2.

4.

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1.

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3.

4.

5.

6.

TOUCHING BLOCKS

ne: ______________________ Date: ______________________

____

EXAMPLE:

1: __________

2: __________

3: __________

4: __________

5: __________

- - - - - - - - - - - - - - - - -

TEST:

1: __________	16: __________
2: __________	17: __________
3: __________	18: __________
4: __________	19: __________
5: __________	20: __________
6: __________	21: __________
7: __________	22: __________
8: __________	23: __________
9: __________	24: __________
10: __________	25: __________
11: __________	26: __________
12: __________	27: __________
13: __________	28: __________
14: __________	29: __________
15: __________	30: __________

SERIAL SOUNDS - B
(Long Series)

. SERIES

.

.

SERIES

6 IN A SERIES

1.

2.

3.

7 IN A SERIES

1.

2.

SERIAL SOUNDS - B
(long series)

Name:______________________________________ **Date:**____________

1. __________________________________
2. __________________________________
3. __________________________________
4. __________________________________
5. __________________________________
6. __________________________________
7. __________________________________
8. __________________________________
9. __________________________________

2 IN A SERIES

1. ____________________________
   ____

3 IN A SERIES

1. ____________________________
   ____
   ____

GO TO
PAGE 2

SERIAL NUMBERS

Name: ______________________________

Date: ______________________________

2: _ _

3: _ _ _

4: _ _ _ _

5: _ _ _ _ _

6: _ _ _ _ _ _

7: _ _ _ _ _ _ _

8: _ _ _ _ _ _ _ _

9: _ _ _ _ _ _ _ _ _

8: _ _ _ _ _ _ _ _

7: _ _ _ _ _ _ _

6: _ _ _ _ _ _

WORD PRODUCTION (Letters)

ne: ______________________ Date: ______________________

Appendix III CLB AND REACTION TIME DATA;

X_1 : HAND SCORE

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
14.409	4.084	.503	16.676	28.341	66
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
6	18	12	951	14787	69

X_2 : SER. SOUNDS

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.517	1.098	.099	1.206	212.247	124
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
-1.724	3.191	4.915	64.163	181.56	11

X_3 : SER. NUMBERS

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.357	.938	.084	.879	262.428	124
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
-2.04	2.483	4.523	44.302	123.954	11

X_4 : WORD PROD.-L

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.62	1.038	.093	1.076	167.385	124
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
-1.579	4.69	6.269	76.859	180.038	11

X_5 : WORD PROD.-C

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.98	1.095	.098	1.199	111.779	124
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
-2.591	4.291	6.882	121.471	266.47	11

X_6 : LOCALISATION

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
1.513	1.037	.093	1.075	68.514	124
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
-2.369	3.621	5.99	187.646	416.18	11

X_7 : 3D ROTATION

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.827	.981	.088	.962	118.641	124
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
-1.304	2.72	4.024	102.488	202.979	11

X_8 : FORM COMPL.

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.713	.95	.085	.902	133.147	124
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
-2.05	2.393	4.443	88.44	174.001	11

X_9 : TOUCH. BLOCKS

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.451	.785	.07	.616	174.212	124
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
-2.183	1.59	3.773	55.867	100.945	11

X_{10} : PROPOSITIONAL

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.613	.725	.065	.525	118.247	124
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
-1.664	2.942	4.606	75.981	111.131	11

X_{11} : APPOSITIONAL

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.876	.667	.06	.445	76.1	124
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
-1.1	2.226	3.326	108.637	149.852	11

X_{12} : R. HEMISPHERICITY

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.264	.839	.075	.704	318.177	124
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
-2.557	2.135	4.692	32.691	95.166	11

X_{13} : COG. SCORE

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
.744	.556	.05	.309	74.74	124
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
-1.369	1.85	3.219	92.237	106.628	11

X_1 : R.T. (same)

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
409.386	290.663	28.922	84484.939	71	101
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
-36	1729	1765	41348	25375792	75

X_2 : R.T. (opp)

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
418.396	357.091	35.532	127513.702	85.348	101
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
79	3308	3229	42258	30431950	75

X_3 : SRT(Y)

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
608.32	171.955	18.875	29568.578	28.267	83
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
368.845	1148.742	779.897	50490.539	3.314E7	93

X_4 : SRT(N)

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
646.837	174.967	19.205	30613.491	27.05	83
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
394.623	1149.583	754.961	53687.507	3.724E7	93

X_5 : HASH(S)

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
694.475	190.779	21.741	36396.676	27.471	77
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
434.3	1595	1160.7	53474.6	39902937.58	99

X_6 : ABC(S)

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
1099.086	437.485	49.856	191393.171	39.804	77
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
582.5	3324.4	2741.9	84629.6	1.076E8	99

X_7 : HASH(OPP)

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
796.527	181.108	20.639	32800.264	22.737	77
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
524.6	1408.6	884	61332.6	51345908.7	99

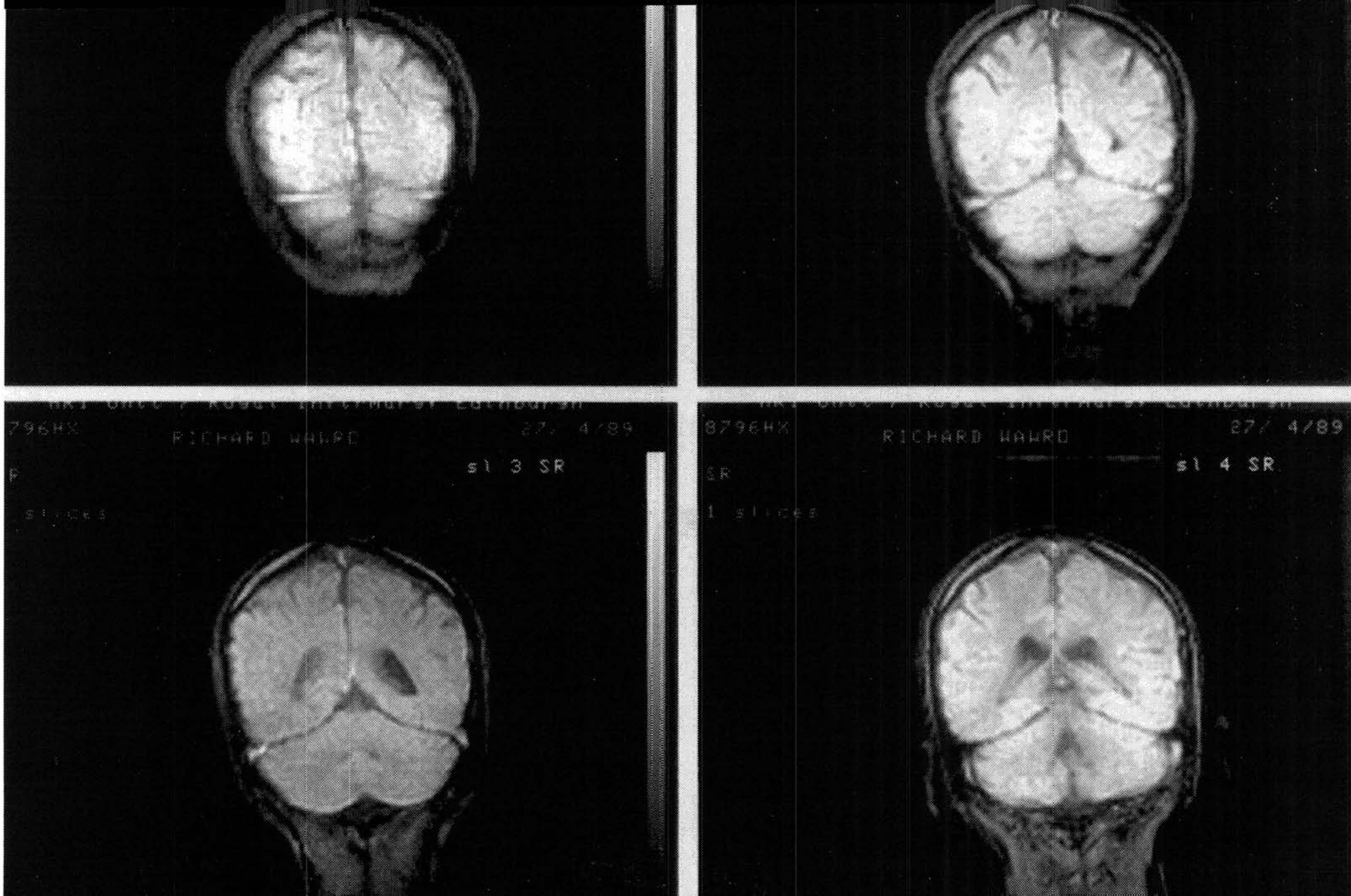
X_8 : ABC(OPP)

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
1224.187	504.853	57.533	254876.558	41.24	77
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
694.9	4717.1	4022.2	94262.4	1.348E8	99

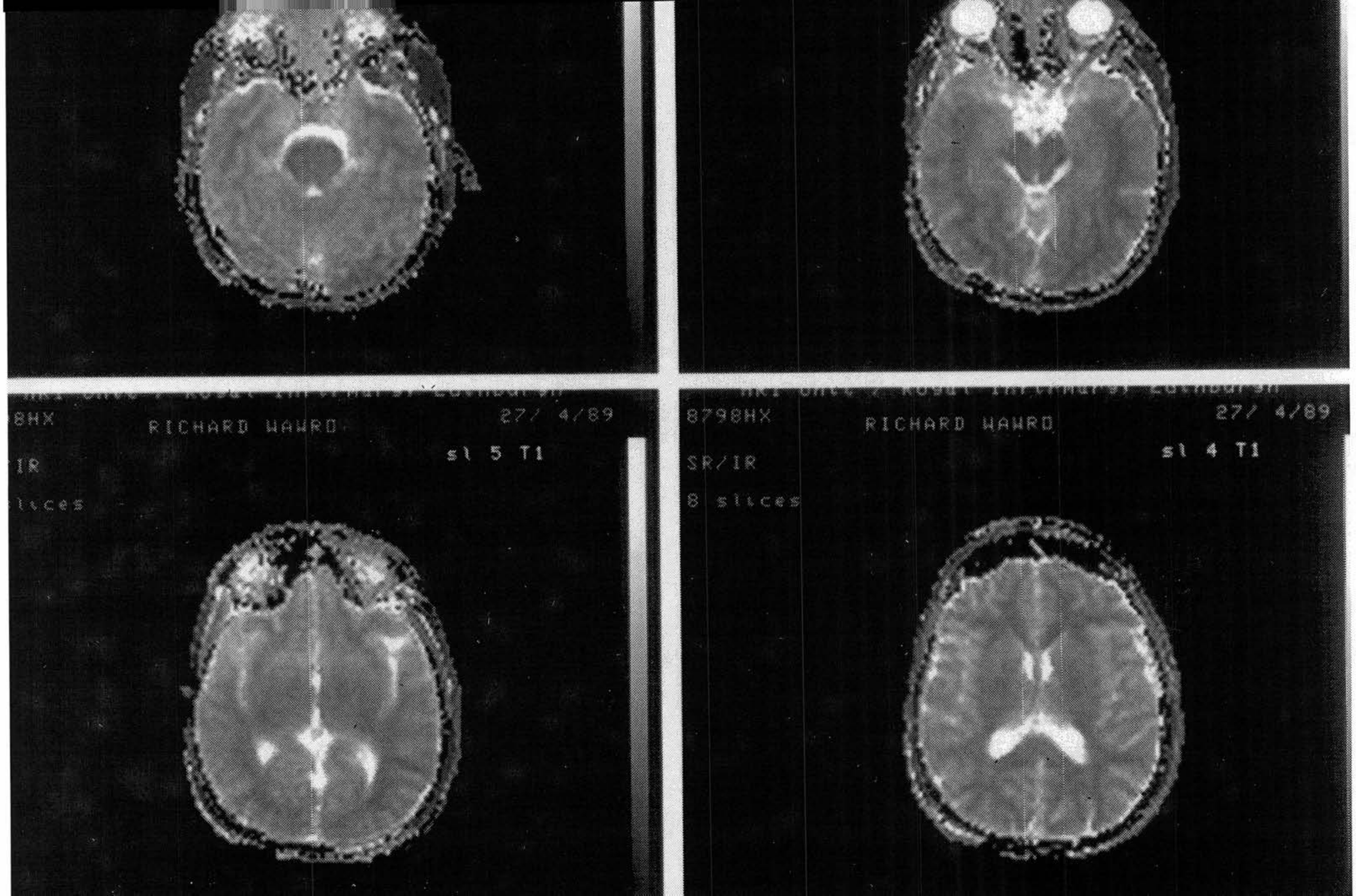
X_9 : M&D-MEANS

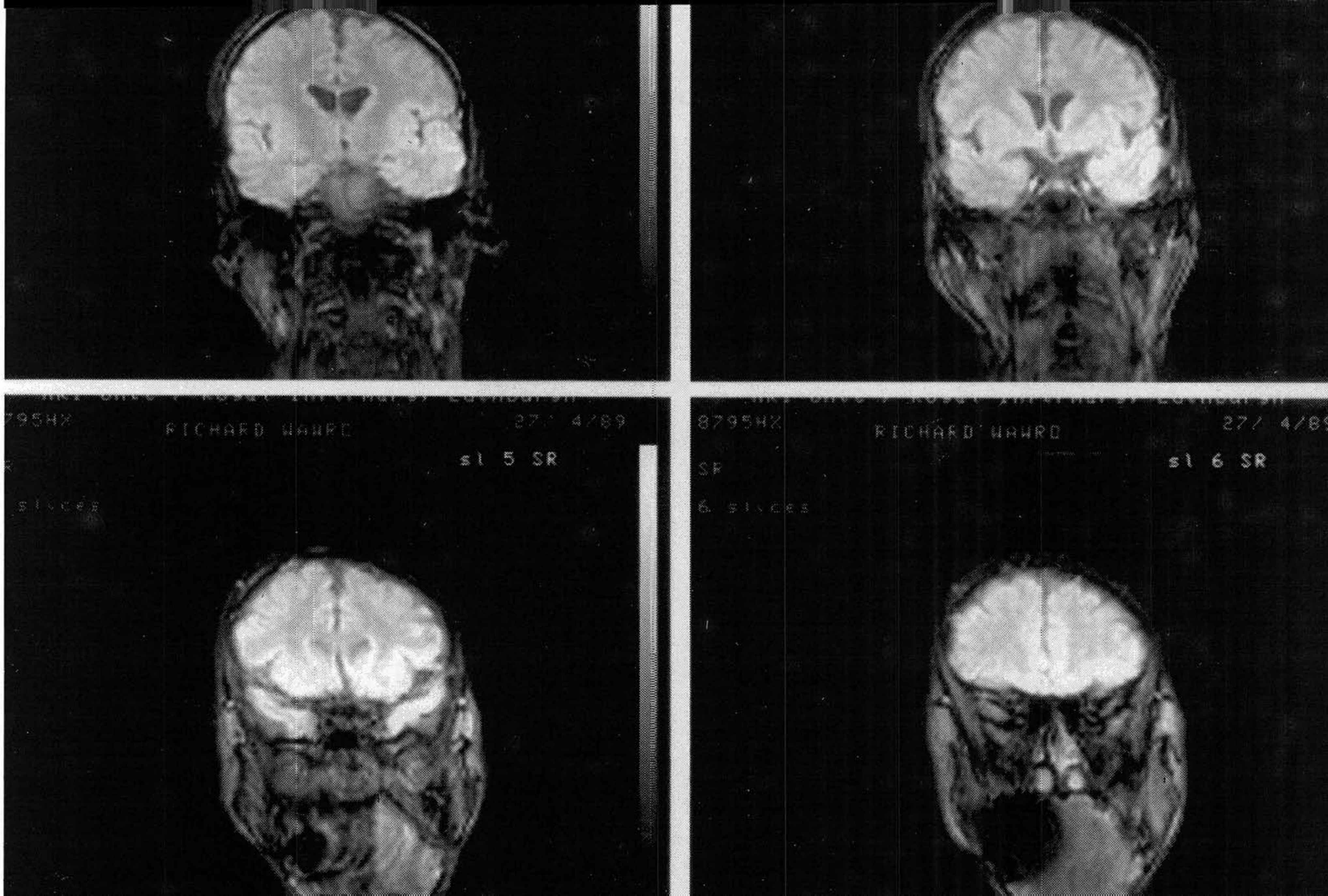
Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
956.711	287.534	27.049	82675.776	30.054	113
Minimum:	**Maximum:**	**Range:**	**Sum:**	**Sum of Sqr.:**	**# Missing:**
599.8	2761.275	2161.475	108108.3	1.127E8	63

Appendix IV : NMR BRAIN SCANS OF RICHARD WAWRO-VARIOUS VIEWS



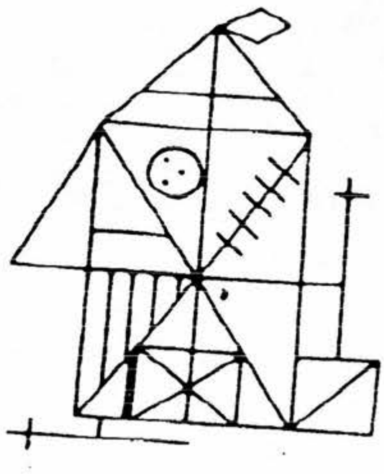
796HX
RICHARD WAWRD
27/ 4/89
sl 3 SR
8796HX
RICHARD WAWRD
27/ 4/89
sl 4 SR
SR
1 slices

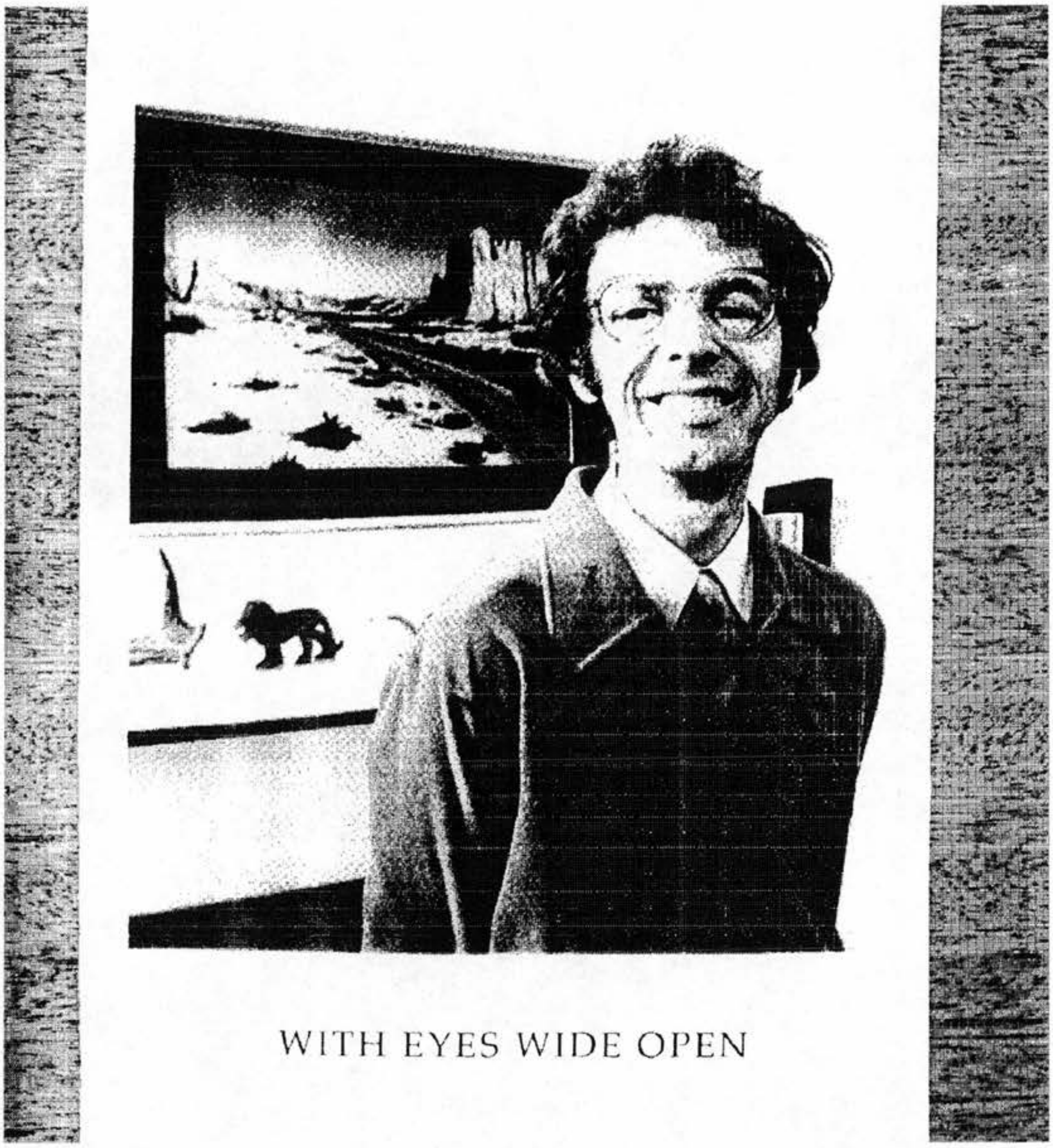

8HX
RICHARD WAWRD
27/ 4/89
sl 5 T1
IR
8798HX
RICHARD WAWRD
27/ 4/89
sl 4 T1
SR/IR
8 slices


8795HZ
RICHARD WAWRO
27/ 4/89
SF
sl 6 SR
6 slices
RICHARD WAWRO
27/ 4/89
sl 5 SR

Appendix V: SAVANT AND PRECOCIOUS ARTIST IMAGES

BELOW: THE REY-OSTERREITH FIGURE





RICHARD WAWRO: PHOTO PORTRAIT FOR THE VIDEO "WITH EYES WIDE OPEN"

RICHARD WAWRO:

ne development of an artist

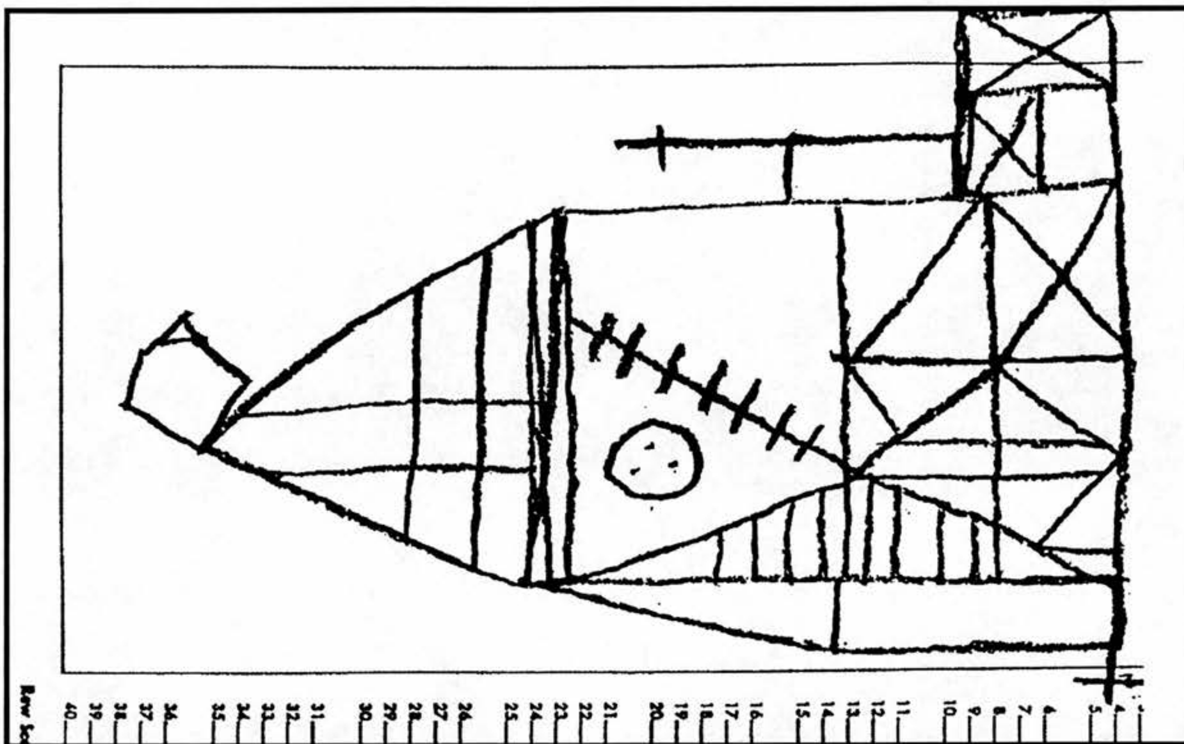
vorks from the ages of six – thirty six

3-rd October to the 4-th Nov. 1988

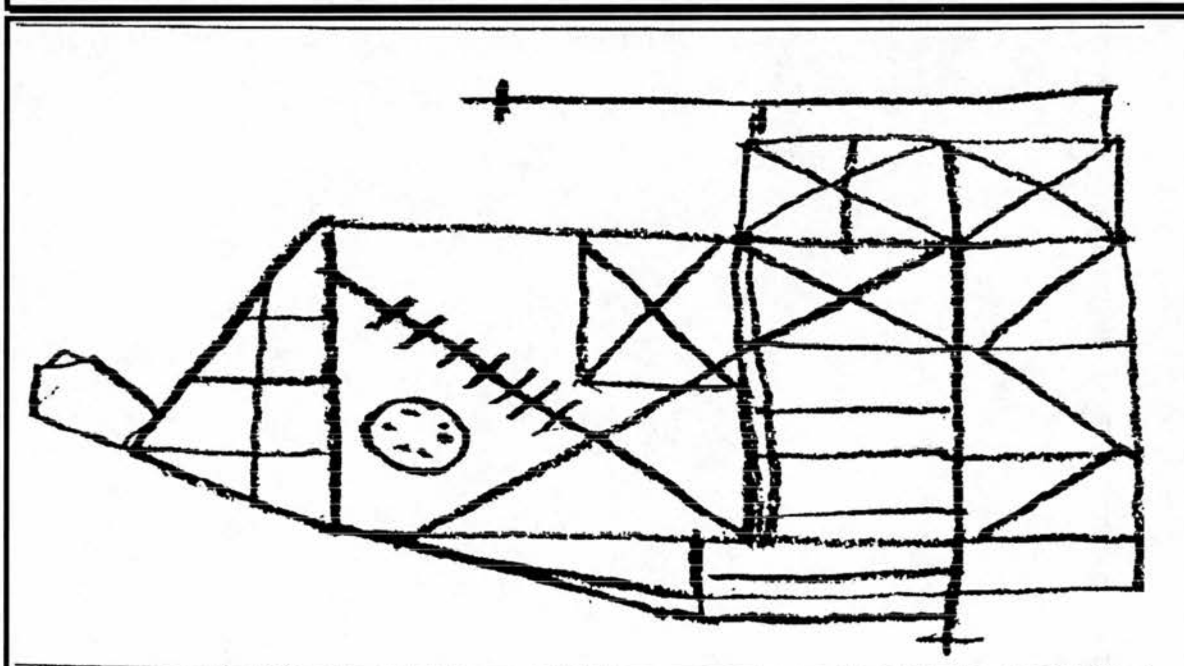
Department of Psychology - Edinburgh University
ge Square

Admission free

n Exhibition which demonstrates how one man defeatea
ntal and physical handicap to grow and develop as
st. His great achievement may be seen in this
ial chronology



RICHARD'S REY-OSTERREITH FIGURE-COPY



RICHARD'S REY-OSTERREITH FIGURE-MEMORY

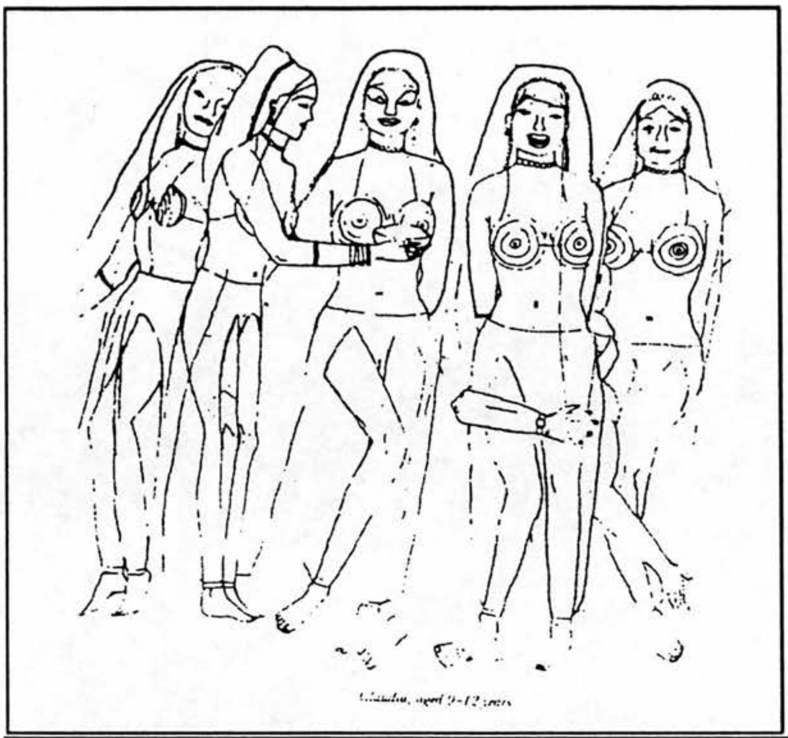
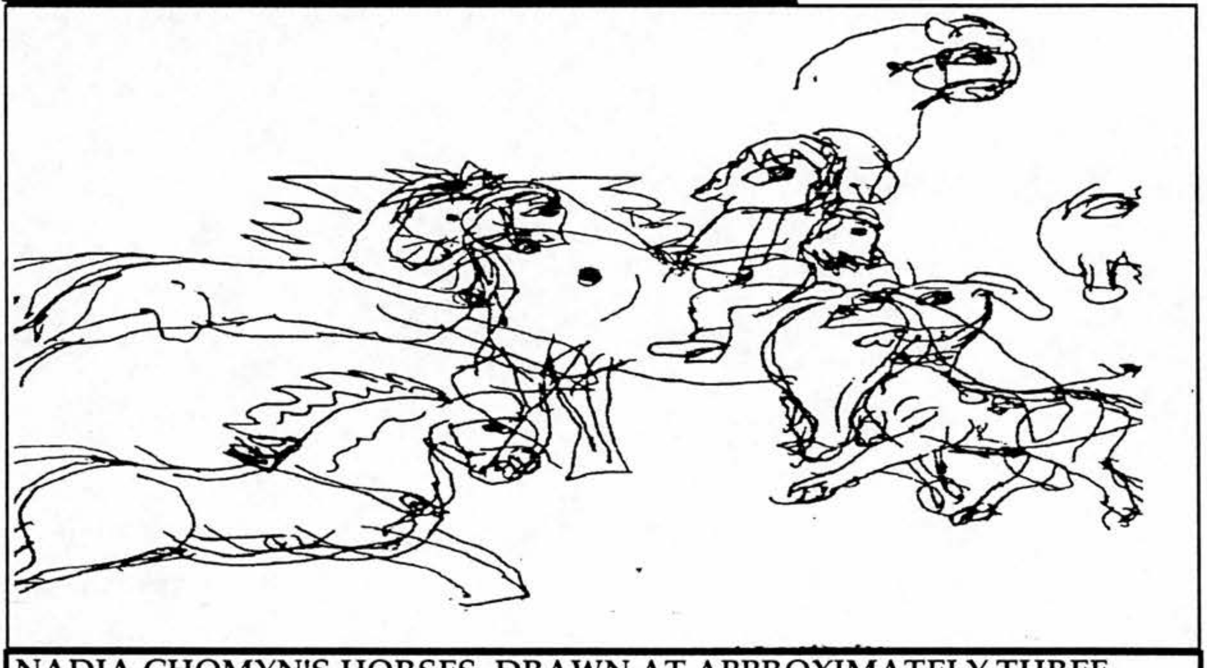
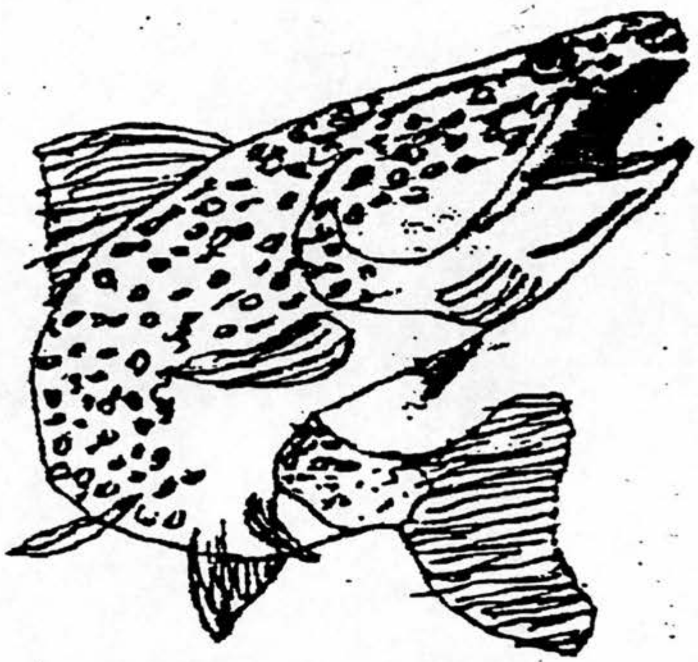


FIGURE FOUR: CLAUDIA'S WOMEN (ADAPTED FROM SELFE, 1983)

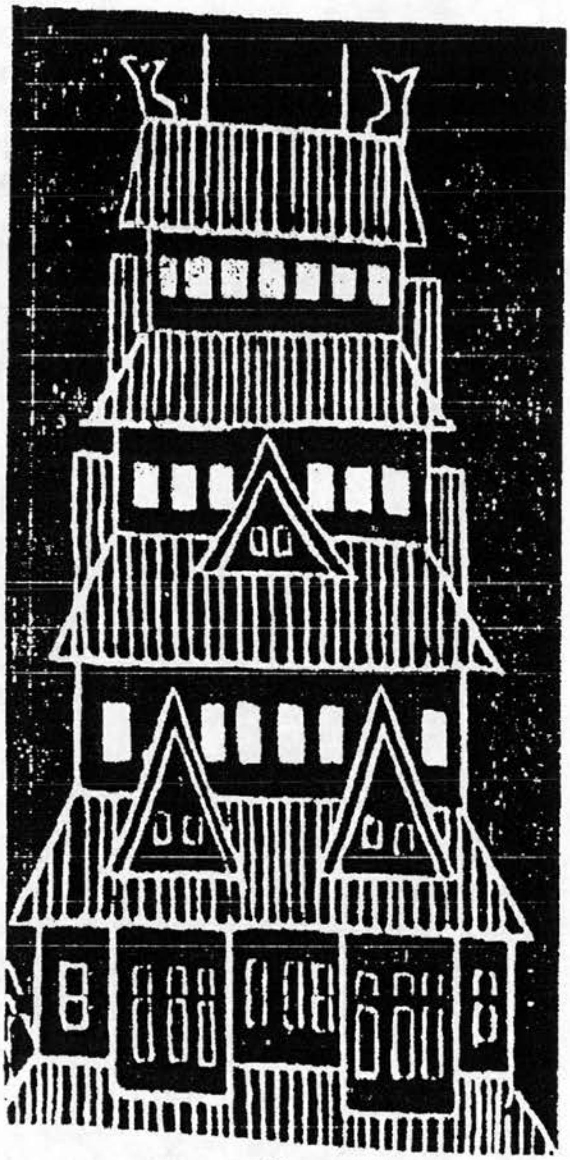


NADIA CHOMYN'S HORSES, DRAWN AT APPROXIMATELY THREE YEARS [ADAPTED FROM SELFE, 1983]



JOSE'S FISH (ADAPTED FROM SACKS, 1985)

Since Yamamoto disliked speech t
Kawasaki encouraged Yamamoto to
picture diary to express his life. As
moto's picture diary improved, Ka
began to reconsider the necessity of
moto's speech therapy. With his p
approval, a special curriculum emph
artwork was instituted. With its inc
Yamamoto began to be more active at
With teacher assistance, he now in
narrative descriptions with his picture
However, his speech improvemen
limited.



Nagoya Castle
(produced by Yamamoto in the seventh grade).

Yamamoto's Artwork

Yamamoto's artworks at the beg
were reported to be copied stereotype
toons. However, one day his accurate
of the Nagoya Castle surprised Kaw
who found that Yamamoto's human sh
were poor and that the dark coloring
Yamamoto used destroyed much of his
Yamamoto used destroyed much of his
Kawasaki's decision to emphasize prin
niques rather than painting seemed to
helped Yamamoto's work. Kawasaki
ciated the degree to which Yamamoto
ture expression accurately reflected the
machine-like life style.

YAMAMOTO'S NAGOYA CASTLE [ADAPTED FROM MORISHIMA, 1974]

BIBLIOGRAPHY:

Albano, A.M., Abraham, N.B., *et al*, Lasers and Brains: Complex Systems with Low-dimensional Attractors, in Mayer-Kress {ed.}, **Dimensions and Entropies in Chaotic Systems,** U.S.A.: Springer, 1986.

Altshuler, K.Z., and Brebbia, D.R., Sleep Patterns and EEG Recordings in Twin Idiot Savants, **Diseases of the Nervous System**, 29, 722-774, 1968.

American Psychiatric Association, **DSM-III-R**, USA: Washington, 1987.

Anon., Ganesh Sittapalam Reports, **The Times**, 19/8/88 and **Daily Telegraph**, 14/7/92.

Anon., Elizabeth Fraser Report on Female Maths students at Edinburgh, **Times Higher Education Supplement**, w/e 23/7/88

Anon., Innovation at Science '89, **The Sunday Times**, 17/9/89.

Anon., **Independent**, 27/6/91.

Anon. 'Biological link' in brains of gay men, **Independent**, 30/8/1991.

Annett, M., and Kilshaw, D., Mathematical ability and lateral asymmetry, **Cortex**, 18: 547-568, 1982.

Annett, M., **Left, Right, Hand and Brain: The Right Shift Theory**, London: Erlbaum, 1985.

Ashton, G.C., Myopia and Cognitive Ability, **Behaviour Genetics**, 13, p.526, 1983.

Asperger, H., Die "autischen Psychopathen" im Kindesalter, **Archiv fur Psychiatrie und Nervenkrankheiten**, 117: 76-136, 1944, translation by U. Frith {ed.} in **Autism and Asperger Syndrome**, U.K.:Cambridge, 1991.

Babloyantz, A., Evidence of Chaotic Dynamics of Brain Activity During the Sleep Cycle, in G. Meyer-Kress {ed.}, **Dimensions and Entropies in Chaotic Systems: Quantifications of Complex Behaviour**, U.S.A: Springer, 1986.

Badian, N., Birth Order, Maternal Age, Season of Birth, and Handedness, **Cortex**, 19: 451-463, 1983.

Bak, P., and Chen, K., Self-Organized Criticality, **Scientific American**, January: 1991.

Ballantyne, A., Hormone opens the door to success, **Sunday Times**, 22/7/1990.

Barnsley, R.H., Thompson, A.H., and Barnsley, P.E., Hockey success and birthdate:

The relative age effect, **Canadian Association for Health, Physical Education and Recreation**, 51: 23-28, 1985.

Baron, M., and Gruen, R., Risk Factors in Schizophrenia: Season of Birth and Family History, **British Journal of Psychiatry**, 152, pp.460-465, 1988.

Barr, W.B., Jaffe, J., Wasserstein, J., Michelson, W.J., Stein, B.M., Regional Distribution of Cerebral Arteriovenous Malformations: Interactions With Sex and Handedness, **Archives of Neurology**, Vol. 46, April, pp. 410-412, 1989.

Becker, B.J., The relationship of spatial ability to sex differences in the performance of mathematically precocious youths on the mathematical sections of the Scholastic Aptitude Test, Master's Thesis, The Johns Hopkins University, 1978.

Becker, J.T., Bass, S.M., Dew, M.A., Kingsley, L., Selnes, O.A., and Sheridan, K., Hand preference, immune disorder and cognitive function among gay/bisexual men: the Multicenter AIDS Cohort Study (MACS), **Neuropsychologia**, Vol. 30, No. 3, pp. 229-235, 1992.

Becker, L.A., Designing Environments for Optimum Growth: Meeting the Needs of Learners with Special Gifts, a project demonstrating excellence, submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, January, 1980, Union Graduate School, The Union for Experimenting Colleges and Universities.

Beer, J., and Fleming, P., Eye Colour and Motor Performance in Physical Education Activities in Elementary School Children, **Perceptual and Motor Skills**, 64: 963-967, 1987.

Beer, J., and Fleming, P., Effects of Eye Colour on Set Shots in Basketball Pig Contests, **Perceptual and Motor Skills**, 65: 885-886, 1987.

Beer, J., and Neeley, M., Effects of Eye Colour on Typing Speed, **Perceptual and Motor Skills**, 65: 893-894, 1987.

Beer, J., and Fleming, P., Effects of Eye Colour on Frisbee Tossing, **Perceptual and Motor Skills**, 66: 675-676, 1988.

Beer, J., and Fleming, P., Effects of Sex and Eye Colour on Jumping Rope by Elementary School Children, **Perceptual and Motor Skills**, 66: 837-838, 1988.

Beer, J., and Beer, J., Relationship of Eye Colour to Winning Horseshoe Pitching Contests, **Perceptual and Motor Skills**, 68: 136138, 1989.

Beer, J., and Fleming, P., Effects of Eye Colour on the Accuracy of Ball Throwing of Elementary School Children, **Perceptual and Motor Skills**, 68: 163-166, 1989.

Beer, J., Fleming, P., and Knorr, W., Relationship of Eye Colour and Sex on Accuracy in Archery, **Perceptual and Motor Skills**, 68: 389-390, 1989.

Beer, J., and Fleming, P., Relations of Eye Colour to Scores on Bruininks-Oseretsky Test of Motor Profiency-Short Form, **Perceptual and Motor Skills**, 68: 859-862, 1989.

Belson, William A., Tape recording: its effect on accuracy of response in survey interviews, **Journal of Marketing Research**, 4, pp. 253-260, August, 1967.

Benbow, C., and Benbow, R.M., Biological Correlates of High Mathematical Reasoning Ability in G.J. De Vries {ed.} **Progress in Brain Research**, 61, Amsterdam: Elsevier, 1984.

Benbow, C., Physiological Correlates of Extreme Precocity, **Neuropsychologia**, Vol. 24(5), pp.719-725, 1986.

Benbow, C., Sex differences in mathematical reasoning ability in intellectually talented pre-adolescents: their nature, effects, and possible causes, **Behavioural and Brain Sciences**, 11 {2}, 1988.

Benson, D.F., and Geschwind, N., The alexias, in P.J. Vinken and G.W. Bruyn {eds.}, **Handbook of Clinical Neurology**, Vol. 4, Amsterdam: Elsevier, 1969.

Berg, J.M., and Stern, J., Iris Colour in Phenylketonuria, **Annals of Human Genetics**, 22: 370-372, 1958.

Betancur, C., Velez, A., Cabanieu, G., Le Moal, M., Neveu, P.J., Association between left-handedness and allergy: a reappraisal, **Neuropsychologia**, Vol. 28, No. 2, pp. 223-227, 1990.

Bentin, S., and Gordon, H.W., Assessment of cognitive asymmetries in brain damaged and normal subjects: Validation of a test battery, **Journal of Neurol, Neurossurg. Psychiatric.**, 42 (8), pp 715-723, 1979.

Bolton, P., Pickles, A., Harrington, R., *et al*, Season of Birth: Issues, Approaches and findings for Autism, **Journal of Child Psychology and Psychiatry**, Vol. 33, No. 3, pp. 509-530, 1992.

Borod, J.C., Kent, J., Koff, E., Martin, C., and Alpert, M., Facial Asymmetry while posing Positive and Negative Emotions: Support for the Right Hemisphere Hypothesis, **Neuropsychologia**, 26: 759-764, 1988.

Braak, H., **Architectonics of the Human Telencephalic Cortex**, Berlin: Springer, 1980.

Bradshaw, J.L., and Nettleton, N.C., The nature of hemispheric specialization in man, **Behavioural and Brain Sciences**, 4: 51-91, 1981.

Brent, S.B., Prigogine's model for self-organization in nonequilibrium systems, **Human Development**, 21: 374-387.

Brill, A.A., Some peculiar manifestations of memory with special reference to lightning calculators, **The Journal of Nervous and Mental Disease**, 92 {6}, December: 709-726, 1940.

Brown, J.W., and Podosin, R., A syndrome of the neural crest, **Archives of Neurology**, 15: 294-301, 1966.

Brown, P., Pollution and Grangetown Report, **The Guardian**, 22/8/90.

Brunner, R.J., Kornhuber, H.H., Seemuller, E., Sugar, G., and Wallesch, C-W., Basal ganglia participation in language pathology, **Brain and Language**, 16: 281-299, 1982.

Bryden, M.P., McManus, I.C., and Steenhuis, R.E., Handedness is not related to self-reported disease incidence, **Cortex**, 27, pp. 605-611, 1991.

Burnett, S.A., Spatial visualization and mathematical reasoning abilities, Peer Commentary, C. Benbow, Sex differences in mathematical reasoning...., **Behavioural and Brain Sciences**, 11 {2}: 187-188, 1988.

Casey, M.B., Nuttall, R.L., Differences in feminine and masculine characteristics in women as a function of handedness: support for the Geschwind/Galaburda theory of brain organisation, **Neuropsychologia**, Vol. 28, No. 7, pp. 749-754, 1990.

Castle, D.J., Murray, R.M., Editorial: The neurodevelopmental basis of sex differences in schizophrenia, **Psychological Medicine**, 21, pp. 565-575, 1991.

Changeux, J.P., and Danchin, A., Selective stabilization of developing synapses as a mechanism for the specification of neuronal networks, **Nature**, 267: 705-711, 1976.

Charman, D.K., The cerebral hemispheres appear to function differently in artists and scientists, **Cortex**, 17: 453-458, 1981.

Chavance, M., Dellatolas, G., Bousser, M.G., Amor, B., Grardel, B., Kahan, A., Kahn, M.F., Le Floch, J.P., and Tchobroutsky, Handedness, Immune disorders and information bias, **Neuropsychologia**, Vol. 28, No. 5, pp. 429-441, 1990.

Chay, T.R., and Rinzel, J., Bursting, Beating, and Chaos in an Excitable Membrane Model, **Journal of the Biophysical Society**, 47: 357-366, 1985.

Chen, T.C., Leviton, A., Asthma and Eczema in Children Born to Women With Migraine, **Archives of Neurology**, Vol. 47, Nov., pp. 1227-1230, 1990.

Code, C., **Language, Aphasia, and the Right Hemisphere**, U.K.: Wiley, 1987.

Coltheart, M., Deep dyslexia: a right-hemisphere hypothesis, in **Deep Dyslexia**, pp.

326-380, 1987.

Cook, E.H., Leventhal, B.L., and Freeman, D.K., Serotonin and Measured Intelligence, **Journal of Autism and Developmental Disorders**, Vol. 18, No. 4, 1988.

Cook, N.D., Callosal Inhibition: The Key to the Brain Code, **Behavioural Science**, 29: 98-110, 1984.

Coren, S., and Porac, C., Iris Pigmentation and Visual Geometric Illusions, **Perception**, Vol. 7: 473-477, 1978.

Coren, S., Searleman, A., and Porac, C., Rate of Physical Maturation and Handedness, **Developmental Neuropsychology**, 2(1), pp. 17-23, 1986.

Coren, S., **The Left-Hander Syndrome: The Causes and Consequences of Left-Handedness**, John Murray: London, 1992.

Courchesne, E., Yeung-Courchesne, R., Hesselink, J.R., and Jernigan, T.L. Abnormal Neuroanatomy in a Non-retarded Person with Autism, **Archives of Neurology**, Vol. 44, March: 335-341, 1987.

Courchesne, E., Neuroanatomical systems involved in infantile autism: The implications of cerebellar abnormalities, in G. Dawson {ed.}, **Autism: New Perspectives on diagnosis, nature, and treatment**, N.Y.: Guilford Press, 1989.

Cox, C.M., **The Early Mental Traits of 300 Geniuses; Volume II of Genetic Studies of Genius**, Stanford University Press, California, 1926.

Craft, S., Gourovitch, M.L., Downton, S.B., Swanson, J.M., Bonforte, S., Lateralised Deficits in Visual attention in Males with Developmental Dopamine Depletion, **Neuropsychologia**, Vol. 30, No. 4, pp. 341-351, 1992.

Creel, D.J., Bendel, C.M., Wiesner, G.L., Wirtschafter, J.D., Arthur, D.C., and King, R.A., Abnormalities of the Central Visual Pathways in Prader-Willi Syndrome Associated with Hypopigmentation, **The New England Journal Of Medicine,** Vol. 314, No. 25: 1606-1609, 1986.

Cronbach, L.J., and Meehl, P.E., Construct validity in psychological tests, **Psychological Bulletin**, 52, pp.281-302, 1955.

Cross, P.G., Cattell, R.B., and Butcher, H.J., The Personality Pattern of Creative Artists, **British Journal of Educational Psychology**, 292-299, 1967.

Curtiss, S., **Genie: A psycholinguistic study of a modernday "wild-child"**, N.Y.: Academic Press, 1977.

D'Amico, C., and Kimura, D., Different Sub-groups of Adextrals Based on Speech Lateralization and Ability Patterns, Abstract, **Journal of Clinical and Experimental**

Neuropsychology, Vol. 9, p. 278, 1987.

Damasio, A.R., and Maurer, R.G., A Neurological Model for Childhood Autism, **Archives of Neurology**, Vol. 35, December: 777-786, 1978.

David, A.S., Cutting, J.C., Affect, Affective Disorder and Schizophrenia: A Neuropsychological Investigation of Right Hemisphere Function, **British Journal of Psychiatry**, 156, pp. 491-495, 1990.

Davies, P., **Cosmic Blueprint**, London: Heinemann, 1987.

Dawson, G., Cerebral Lateralization in Autism: Clues to its Role in Language and Affective Development, in D.L. Molfese and S.J. Segalowitz {eds.}, **Brain Lateralization in Children: Developmental Implications**, N.Y./London: The Guilford Press, 1988.

Dawson, G., {ed.}, **Autism: New Perspectives on diagnosis, nature and treatment**, N.Y.: Guildford Press, 1989.

Denes, G., *et al.*, **Perspectives on Cognitive Neuropsychology**, U.K.: Erlbaum, 1988.

Dellatolas, G., Annesi, I., Jallon, P., Chavance, M., and Lellouch, J., An Epidemiological Reconsideration of the Geschwind-Galaburda Theory of Cerebral Lateralisation, **Archives of Neurology**, Vol. 47, July, pp. 778-782, 1990.

Dellatolas, G., *et al*, Note: Birth Order and Month of Birth are not related with Handedness in a sample of 9,370 Young Men, **Cortex**, 27, pp. 137-140, 1991.

Detterman, D.K., What does reaction time tell us about intelligence? in P.A. Vernon {ed.}, **Speed of Information Processing and Intelligence**, New Jersey,: Ablex Pub. Co., 1987.

Deutsch, G., Bourbon, W.T., Papanicolaou, and Eisenberg, H.M., Visuospatial Tasks Compared via activation of Regional Cerebral Blood Flow, **Neuropsychologia**, 26 {3},1988.

Dorner, G., Rhode, W., Stahl, F., Krell, L., and Masius, W.G., A Neuroendocrine Predisposition for Homosexuality in Man, **Archives of Sexual Behaviour**, 4: 1-8, 1975.

Dorner, G., Neuroendocrine Response to Estrogen and Brain Differentiation in Heterosexuals, Homosexuals, and Transsexuals, **Archives of Sexual Behaviour**, Vol. 17, No. 1, pp. 57-75, 1988.

Drevdahl, J.D., Factors of importance for Creativity, **Journal of Clinical Psychology**, 12: 21-26, 1956.

Duckett, J.M., Idiot Savants: Super specialization in mentally retarded persons, Doctoral dissertation, University of Texas at Austin, 1976.

Dudek, S.Z., and Hall, W.B., Some Test Correlates of High Level Creativity in Architects, **Journal of Personality Assessment**, 48 {4}, 1984

Dudek, S.Z., The Architect as Person: A Rorschach Image, **Journal of Personality Assessment**, 48 {6}, 1984.

Deutsch, G., Bourbon, W.T., *et al*, Visuospatial Tasks Compared via activation of Regional Cerebral Blood Flow, **Neuropsychologia**, Vol. 26, No. 3, pp. 445-452, 1988.

Dumas, R., and Morgan, A., EEG asymmetry as a function of occupation, task, and task difficulty, **Neuropsychologia**, Vol. 13: 219-228, 1975.

Dunphy, E.B., The Biology of Myopia, **The New England Journal of Medicine**, 283 {15}, October: 796-800, 1970.

Eagles, J.M., Are Polioviruses a cause of Schizophrenia? **British Journal of Psychiatry**, 160, pp. 598-600, 1992.

Ebert, P.C., and Pollack, R.H., Magnitude of the Muller-Lyer illusion as a function of lightness contrast, viewing time, and Fundus pigmentation, **Psychonometric Science**, Vol. 26 {6}: 347-348, 1972.

Edelman, G.M., **Neural Darwinism: The theory of neuronal group selection**, N.Y.: Basic Books, 1987.

Ellis, A., and Young, A., **Human Cognitive Neuropsychology**, U.K.: Erlbaum, 1988.

Ellis, H., **A Study of British Genius**, London: Hurst and Blackett, 1904.

Errico, A.L., Parsons, O.A., Kling, O. Ray, and King, A. C., Investigation of the Role of Sex Hormones in Alcoholics Visuospatial Deficits, **Neuropsychologia**, Vol. 30, No. 5, pp. 417-426, 1992.

Eysenck, H.J., O Tempora, O Mores! **Behavioural and Brain Sciences**, 11 {2}: p. 189, Peer Commentary on Benbow, C., Sex differences in mathematical reasoning ability..., 1988.

Fallone, A.R., Artistic Prodigies: Can current Child development Theories explain them? Unpublished Undergraduate Dissertation, University of Leicester, June, 1985.

Feldman, D.H., **Beyond Universals in Cognitive Development**, Norwood, N.J.: Ablex, 1980.

Fennema, E., and Tartre, L.A., The use of spatial visualization in mathematics by girls and boys, **Journal for Research in Mathematics Education**, 16 {3}: 184-206, 1985.

Ferguson, R., Personal communication.

Fletcher, H.M., The Corpus Callosum....Contributions to Culture, unpublished Bsc dissertation, University of Edinburgh, 1986.

Fodor, J., **The modularity of mind**, Cambridge, Mass.: MIT Press, 1983.

Fodor, J., Precis of 'The Modularity of Mind', **Behavioural and Brain Science**, 1983.

Fourie, D., Geophysical Variables and Behaviour: XXIV: Seasonal Factors in Extraversion, **Psychological Reports**, 56: 3-8, 1985.

Frank, P., **Einstein, His Life and Times**, London: Cape, 1948.

Fraser, E., The Gender Factor in Mathematics, report in the **Times Higher Education Supplement**, w/e 23/7/88.

Fredericks, J.A.M. {ed.}, Chapter 31, **Handbook of Clinical Neurology**, Vol. 1 {45}: 473-481, Elsevier, 1985.

Freeman, W.J., Dynamics of Image Formation by Nerve Cell Assemblies, in E. Basar, H. Flohr, and A. Mandell {eds.}, **Synergetics of the Brain**, U.S.A.: Springer, 1983.

Freeman, W.J., and Skarda, C.A., Chaotic Dynamics versus representationalism, Authors' Response, Continuing Commentary on How brains make chaos in order to make sense of the world, **Behavioural and Brain Sciences**, 13 {1}: 167-168, 1990.

Freeman, W.J., The Physiology of Perception, **Scientific American**, February, 1991.

Frith, U., **Autism: Explaining the Enigma**, U.K.: Blackwell, 1989.

Frith, U., quoted by O'Sullivan, J., Train spotters "may suffer from autism", **Independent**, 14/9/91.

Fromm, E., **The Anatomy of Human Destructiveness**, London: Penguin, 1973.

Fry, E.N.S., and Hall-Parker, J.B., Eye-hue and the oculocardiac reflex, **British Journal of Opthalmology**, 62: 116-117, 1978.

Gage, J., **Colour in Turner: Poetry and Truth**, U.K.: Studio Vista, 1969.

Galaburda, A., Paper presented at the Rodin Dyslexia Conference, University of North Wales, Bangor, 16th September, 1989.

Gambill, H.D., Ogle, K.N., and Kearns, T.P., Mydriatic effect of 4 drugs determined with pupillograph, **Archives of Opthalmology**, 77: 740-746, 1967.

Gardner, H., **The Shattered Mind**, N.Y.: Vintage Books, 1974.

Gardner, H., **Art, Mind, and Brain: A Cognitive Approach to Creativity**, Basic Books, New York, 1982.

Gardner, H., **Frames of Mind: the theory of multiple intelligences**, New York: Basic Books, 1983.

Gardner, H., The Centrality of modules, Peer Commentary on Fodor's Precis of 'The Modularity of Mind', **Behavioural and Brain Science**, 1983.

Gary, A.L., and Glover, J., Melanin as a Predictor in the Acquisition of Developmental Skills, **The Journal of Psychology**, 90, 185190, 1975.

Gary, A.L, and Glover, J., **Eye Colour, Sex and Children's Behaviour**, Chicago: Nelson Hall, 1976.

Gastpar, M., L-HTP and the Serotonin Hypothesis: Their meaning for treatment of Depression, in J. Obiols, C. Balus, E. Gonzalez, M. Onclus, and J. Pujol {ed.}, **Biological Psychiatry Today**, Amsterdam: Elsevier/North Holland Biomedical Press, 1979.

Gay, D., Dick, G., and Upton, G., Multiple Sclerosis associated with sinusitis: Case-controlled study in General Practice, **The Lancet**, pp. 815-819, 12/4/1986.

Gauquelin, M., Is there a Mars Effect? **Journal of Scientific Exploration**, 2: 29, 1988.

Gazzaniga, M.S., and Sperry, R.W., Language after section of the cerebral commissures, **Brain**, 90: 131-148, 1967.

Gazzaniga, M.S., and Hillyard, S.A., Language and speech capacity of the right hemisphere, **Neuropsychologia**, 9: 273-280, 1971.

Gay, D., Dick, G., and Upton, G., Multiple sclerosis associated with sinusitis: case-controlled study in General Practice, **The Lancet**, 815-819, 12/4/86.

Gellin, G.A., Kopf, A.W., and Garfinkel, L., Malignant Melanoma: A Controlled Study of Possible Associated Factors, **Archives of Dermatology**, Vol. 99, 43-48, 1969.

Geschwind, N., and Galaburda, A.M., Cerebral Lateralization: Biological Mechanisms, Associations, and Pathology: {2} A Hypothesis and a Program for Research, **Archives of Neurology**, Vol. 42, June, 521-562, 1985.

Geschwind, N., and Galaburda, A.M., **Cerebral Lateralization: Biological Mechanisms, Associations, and Pathology**, Camb. Mass./ London: Bradford Books, The MIT Press, 1987.

Getzels, J., and Csikzentmihalyi, M., **The creative vision: a longitudinal study of problem finding in art**, N.Y.: Wiley, 1976.

Gilger, J.W., Pennington, B.F., Green, P., Smith, S.M., and Smith, S., Reading disability, immune disorders and non-right-handedness: twin and family studies of their relations, **Neuropsychologia**, Vol. 30, No. 3, pp. 209-227, 1992.

Gleick, J., **Chaos: Making a New Science**, London: Cardinal/Sphere, 1987.

Goldberg, E., and Costa, L.D., Hemispheric differences in the acquisition and use of descriptive systems, **Brain and Language**, 14: 144-173, 1981.

Goldberger, A.L., and West, B.J., Fractals in Physiology and Medicine, **The Yale Journal of Biology and Medicine**, 60: 421-435, 1987.

Goldberger, A.L., Rigney, D.R., and West, B.J., Chaos and Fractals in Human Physiology, **Scientific American**, February: 34-41, 1990.

Goldman-Rakic, P.S., Topography of Cognition: Parallel Distributed Networks in Primate Association Cortex, **Annual Review of Neuroscience**, 11: 137-156, 1988.

Goldsmith, L.T., and Feldman, D.H., Idiots Savants-Thinking about Remembering: a response to White, **New Ideas in Psychology**, 6 {1}: 15-23, 1988.

Gordon, H.W., Silverberg-Shalev,R., and Czernilas, J., Hemispheric asymmetry in fighter and helicopter pilots, **Acta Psychologia**, 52, pp. 33-40, 1982.

Gordon, H.W., The Learning Disabled are Cognitively Right, **Topics in Learning and Learning Disabilities**, 3 {1}, 1983.

Gordon, H.W., The Cognitive Laterality Battery: Tests of Specialized Cognitive Function, **International Journal of Neuroscience**, 1986.

Gordon, H.W., and Lee, P.A., A Relationship Between Gonadotropins and Visuospatial Function, **Neuropsychologia**, 1986.

Gordon, H.W., Management Success as a Function of Performance on Specialised Cognitive Tests, **Human Relations**, Vol. 40, No. 10, pp. 671-698, 1987.

Gordon, H.W., Specialized Cognitive Function and School Achievement, **Developmental Neuropsychology**, 4 {3}: 239-257, 1988.

Gotz, D.O., and Gotz, K., Personality characteristics of professional artists, **Perceptual and Motor Skills**, 49: 327-394, 1979.

Gray, C.M, and Singer, W., Stimulus-specific neuronal oscillations in orientation columns in cat visual cortex, **Proceedings of the National Academy of Science**, 86* 1698-1702, March, 1989.

Gray, C.R., and Gummerman, K., The Enigmatic Eidetic Image: A critical examination of Methods, Data, and Theories, **Psychological Bulletin**, 82 {3}: 383-407, 1975.

Greiner, A.C., and Nicolson, G.A., Schizophrenia-melanosis, **Lancet**, ii: 1165, 1965.

Griffith Steel, Major J., Gorman, Lt. Col. R., and Flexman, J.E., Neuropsychiatric Testing in an Autistic Mathematical Idiot Savant: Evidence for Nonverbal Abstract Capacity, **Journal of the American Academy of Child Psychiatry**, 23 {6}: 704-707, 1984.

Grobstein, P., On beyond neural specificity: Problems in going from cells to networks and from networks to behaviour, in P.G. Shinkman {ed.}, **Advances in neural and behavioural development**, Vol. 3, N.Y.: Ablex, 158, 1988.

Grunfeld, F.V., **Rodin: A biography**, London: Century Hutchinson, 1988.

Gupta, S., Season of Birth in relation to Personality and blood groups, **Personality and Individual Differences**, Vol. 13, No. 5, pp. 631-633, 1992.

Gupta, S., and Murray, R.M., The Relationship of Environmental Temperature to the Incidence and Outcome of Schizophrenia, **British Journal of Psychiatry**, 160, pp. 788-792, 1992.

Gur, R.E., Skolnick, B.E., Gur, R.C., *et al*, Brain Function in psychiatric disorder: Regional cerebral blood flow in medicated schizophrenia, **Archives of General Psychiatry**, 40, pp. 1250-1254, 1983.

Hall, C., MS theory comes in from the cold, **Independent**, 7/11/90.

Happy, R., and Collins, J.K., Melanin in the ascending reticular activating system and its possible relationship to autism, **Medical Journal of Australia**, 2: 1484-1486, 1972.

Harness, B.Z., Epstein, R., and Gordon, H. W., Cognitive Profile of Children referred to a Clinic for Learning Disabilities, **Journal of Learning Disabilities**, 17 {6}, 1984.

Hecaen, H., and Albert, M.L., **Human Neuropsychology**, N.Y.: Wiley, 1978.

Heim, A.W., and Watts, K.P., Handedness and cognitive bias, **Quarterly Journal of Experimental Psychology**, 28: 263-272, 1976.

Henderson, A.S., Korton, A.E., Jorm, A.F., McCusker, E., Creasey, H., and Broe, G.A., Season of birth for Alzheimer's disease in the Southern Hemisphere, **Psychological Medicine**, 21: 371-374, 1991.

Hentschel, U., Kiessling, M., Season of Birth and Personality: Another Instance of noncorrespondence, **Journal of Social Psychology**, 125 (5), pp. 577-585, 1985.

Hermelin, B.and O'Connor, N., Spatial Representations in Mathematically and in Artistically Gifted Children, **British Journal of Educational Psychology**, 56, pp.150-157, 1986.

Hermelin, B., and O'Connor, N., Idiot savant calendrical calculators: rules and regularities, **Psychological Medicine**, 16: 885-893, 1986.

H.M.S.O., **Mortality Statistics: Area**, 1988.

Hier, D.B., and Crowley, W.F., Spatial Ability in Androgen-Deficient Men, **The New England Journal of Medicine**, Vol. 306, No. 20, 1982.

Hill, A.L., Savants: A categorization of abilities, **Mental Retardation**, 12 {6}: 12-13, 1974.

Hill, A.L., An investigation of calendar calculating by an idiot savant, **American Journa; of Psychiatry**, 132: 557-560, 1975.

Hill, A.L., Idiot Savants: Rate of Incidence, **Perceptual and Motor Skills**, 44: 161-162, 1977.

Hill, A.L., Idiot Savants: Sensory/Motor deficits and gender, **International Journal of Rehabilitation Research**, 1 {1}: 81-83, 1978.

Hill, A.L, Savants: Mentally Retarded Individuals with Special Skills, in N.R. Ellis {ed.}, **International Review of Research in Mental Retardation**, Vol. 9, N.Y./San Francisco/London: Academic Press, 1978.

Hirshkowitz, M., Earle, J., and Paley, B., EEG alpha asymmetry in musicians and nonmusicians: a study of hemispheric specialization, **Neuropsychologia**, 16: 125-128, 1978.

Hoffman, E., The Idiot Savant: A Case Report and a Review of Explanations, **Mental Retardation**, 9 {4}:18-21, 1971.

Holstein, A.P., [Discussion] of Horwitz, W.A., Kestenbaum, C., Person, E., and Jarvik, L., Identical twin-idiot-savants-calendar calculators, **American Journal of Psychiatry**, 121: 1075-1079, 1965.

Horwitz, W.A., Kestenbaum, C., Persons, E., and Jarvik, L., Identical Twin Idiot Savants Calendar Calculators, **American Journal of Psychiatry**, 121, pp. 1075-1079, 1965

Howe, M., **Fragments of Genius: The Strange Feats of Idiot Savants**, London/N.Y.: Routledge, 1989.

Howe, M., The Strange Achievements of Idiots Savants, in **Psychological Survey** 7, U.K.: B.P.S. Pub., 1990.

Jackson, H., The duality of the brain, **Medical Press Circ.**, 1:19, 41, 63, 1874.

Jaensch, E., and Menher, H., Feats of memory in a feebleminded man, **Psychiatric Abstracts**, Part 2 {2702}, 1928.

Jahoda, G., Retinal Pigmentation, Illusion Susceptibility and Space Perception, **International Journal of Psychology**, Vol. 6, No. 3: 199-208, 1971.

Jamison, K.R., Mood Disorders and Patterns of Creativity in British Writers and Artists, **Psychiatry**, Vol. 52, May, 1989.

Jones, H.E., Phenomenal Memorizing as a "Special Ability", **The Journal of Applied Psychology**, Vol. X, No. 3, 1926.

Kaas, J., The Organization of Neocortex in Mammals: Implications for theories of Brain formation, **Annual Review of Psychology**, 38: 129-151, 1987.

Kaczmarek, L.K., and Babloyantz, A., Spatiotemporal patterns in epileptic seizures, **Biological Cybernetics**, 26: 199, 1977.

Karlsson, J.L., Genetic relationship between giftedness and myopia, **Hereditas**, 73, pp. 85-88, 1973.

Karlsson, J.L., Influence of the Myopia gene on brain development, **Clinical Genetics**, 8, pp. 314-318, 1975.

Karnes, F.A., Chauvis, J.C., and Trant, T.J., Comparison of Personality Profiles for Intellectually Gifted Students and Students Outstanding in the Fine and Performing Arts attending Self-Contained Secondary Schools, **Psychology in the Schools**, 22, pp. 122-126, April, 1985.

Kastein, S., and Trace, B., **The Birth of Language: The Case History of a Non-Verbal Child**, Springfield, Il.: Charles C. Thomas, 1986.

Katz, A.N., The relationships between creativity and cerebral hemisphericity for creative architects, scientists, and mathematicians, **Empirical Studies of the Arts**, Vol. 4 {2}, 1986.

Karlsson, J.L., Genetic relationship between giftedness and myopia, **Hereditas**, 73: 85-88, 1973.

Karlsson, J.L., Influence of the Myopia gene on brain development, **Clinical Genetics**, 8: 314-318, 1975.

Karnes, F.A., Chauvis, J.C., and Trant, T.J., Comparison of Personality Profiles for Intellectually Gifted Students and Students Outstanding in the Fine and Performing Arts attending Self-Contained Secondary Schools, **Psychology in the Schools**, 22: 122-126, April, 1985.

Kauffman, S.A., Antichaos and Adaptation, **Scientific American**, August: 64-70, 1991.

Kendall, R.E., and Adams, W., Unexplained Fluctuations in the Risk for Schizophrenia by Month and Year of Birth, **British Journal of Psychiatry**, 158: 758-763, 1991.

Kent, I., Human Iris Pigmentation: 1. A concept of individual reactivity with implications in health and disease, **Canadian Psychiatric Association Journal**, 1: 99-104, 1956.

Kinsbourne, M., The minor cerebral hemisphere as a source of aphasic speech, **Archives of Neurology**, 25: 302-306, 1971.

Kirk, U., Hemispheric Contributions to the Development of Graphic Skill, in C.T. Best {ed.}, **Hemispheric Function and Collaboration in the Child**, N.Y./London: Academic Press, 1985.

Kline, P., **Intelligence: The Psychometric View**, London: Routledge, 1991.

Knobloch, H., and Pasamanick, B., Seasonal variations in the births of the mentally deficient, **American Journal of Public Health**, 48: 1201-1208, 1958.

Kohonen, T., **Self-organization and associative memory**, U.S.A.: Springer, 1984.

Korein, J., Iris Pigmentation [Melanin] in Idiopathic Dystonic Syndromes including Torticollis, **Annals of Neurology**, Vol. 10, No. 1, 53-55, 1981.

Kugler, P.N., A Morphological Perspective on the Origin and Evolution of Movement Patterns, in M.G. Wade and H.T.A. Whiting {eds.}, **Motor Development in Children: Aspects of Co-ordination and Control**, Dordrecht/Boston/Lancaster: Martinus Nijhoft, 1986.

Kushnir, M., Gordon, H.W., and Heifetz, A., Cognitive asymmetries in bipolar and unipolar depressed patients, paper presented at the 8th Annual Meeting of the International Neuropsychological Society, San Francisco, 1980.

Kris, E., and Kurz, J., **Legend, Myth, and Magic in the Image of the Artist: A Historical Experiment**, Yale University Press, 1979.

LaFontaine, L., Divergent Abilities in the Idiot Savant, Doctor of Education dissertation, Boston University School of Education, 1974.

Landers, D.M., Obermeier, G.E., and Patterson, A.H., Iris pigmentation and reactive motor performance, **Journal of Motor Behaviour**, 8 {3}, 171-179, 1976.

Langan, S.J., Deary, I.J., Hepburn, D.A., and Frier, B.M., Cumulative cognitive impairment following recurrent severe hypoglyceamia in adult patients with insulin-treated diabetes mellitus, **Diabetologia**, 34: 337-344, 1991.

Lashley, K.S., **Brain Mechanisms and Intelligence**, N.Y.: Dover, 1963; first published 1929, Chicago: U.O.E.P.

Lean, G.A., and Clements, M.A., Spatial ability, visual imagery, and mathematical performance, Report No. 10, Lae: Papua New Guinea University of Technology, Mathematics Education Centre, 1981.

Lebrun, Y., Van Endert, C., and Szliwowski, H., Trilingual Hyperlexia, in Obler and Fein {eds.}, **The Exceptional Brain**, 1988.

Lester, D., **A Physiological Basis for Personality Traits: A New Theory of Personality**, Springfield, U.S.A.: Charles Thomas, 1974.

Levin, A., Dustin Hoffman and the Amazing Rain Boy, **The Mail on Sunday "You" Magazine**, May 21st, 1989.

Levy, J., Information Processing and Higher Psychological Functions in the Disconnected Hemispheres of Human Commisurotomy Patients, PhD Thesis, California Institute of Technology, 1970.

Levy, J., Nebes, R.D., and Sperry, R.W., Expressive language in the surgically separated minor hemisphere, **Cortex**, 8, pp. 49-58, 1971.

Levy, J., and Trevarthen, C., Perceptual, semantic and phonetic aspects of elementary language processes in split-brain patients, **Brain**, 100: 105-118, 1977.

Lindesay, J., Laterality Shift in Homosexual Men, **Neuropsychologia**, 25: 965-969, 1987.

Logan, C., Clumsy children "worst at maths", **Sunday Express**, 16/12/90.

p. 1051, **Longman Dictionary of the English Language**, 1984.

Lord, R., and Hulme, C., Patterns of Rotary Pursuit Performance in Clumsy and Normal Children, **Journal of Child Psychology and Psychiatry**, 29 {5}: 691-701, 1988.

Lucas, J.A., Rosenstein, L.D., and Bigler, E.D., Handedness and language among the mentally retarded: implications for the model of pathological left-handedness and gender differences in hemispheric specialisation, **Neuropsychologia**, Vol. 27, No. 5, pp. 713-723, 1989.

Lucci, D., Fein, D., Holevas, A., and Kaplan, E., Paul: A Musically Gifted Autistic Boy, Chapter 17 in Obler and Fein, **The Exceptional Brain**, 1988.

Luria, A.R., **The Mind of a Mnemonist**, N.Y.: Basic Books, 1968.

Luria, A.R., **The Working Brain: An Introduction to Neuropsychology**, Trans. Basil Haigh, U.K.: Penguin Books, 1973.

Luszki, W.A., An Idiot Savant on the WAIS? **Psychological Reports**, 19: 603-609, 1966.

Lynch, G., What memories are made of, **The Sciences**, New York Academy of Sciences, 25: 38-43, 1985.

Maccoby, E., and Jacklin, C., **The Psychology of Sex Differences**, U.S.A.: Stanford University Press, 1974.

Maccoby, E. and Maccoby, N., The interview: a tool of social science, in G. Lindzey, (ed.) **Handbook of Social Psychology**, Vol. 1, Cambridge, Mass., Addison-Wesley.

MacCulloch, M.J., and Waddington, J.L., Neuroendocrine Mechanisms and the Aetiology of Male and Female Homosexuality, **British Journal of Psychiatry**, 139, pp. 341-345, 1981.

Macfarlane-Smith, I., **Spatial Ability: Its Educational and Social Significance**, London: U.L.P., 1964.

MacQuarrie, T.W., **MacQuarrie Test of Mechanical Ability**, Monterey, CA.:California Test Bureau, 1953.

Mann, J.J., McBride, P.A., Brown, R.P., *et al*, Relationship between Central and Peripheral Serotonin Indexes in Depressed and Suicidal Psychiatric Inpatients, **Archives of General Psychiatry**, Vol. 49, June, 1992.

Manoach, D.S., Maher, B.A., and Manschrek, T.C., Left-handedness and Thought disorder in the Schizophrenias, **Journal of Abnormal Psychology**, Vol. 97, No. 1, pp. 97-99, 1988.

Marcell, T., Surface dyslexia and beginning reading: a revised hypothesis of the pronunciation of print and its impairments, in M. Coltheart, K. Patterson, and J.C. Marshall, **Deep Dyslexia**, 2nd. edition, London/N.Y.: Routledge and Kegan Paul, 1987.

Marchant-Haycox, S.E., McManus, I.C., and Wilson, G.D., Left-handedness, homosexuality, HIV infection and AIDS, **Cortex**, 27, pp. 49-56, 1991.

Markle, A., Colour and Form Perception on the Rorschach as a Function of Eye Colour, **Perceptual and Motor Skills**, 41: 831-834, 1975.

Markle, A., Eye colour and responsiveness to arousing stimuli, **Perceptual and Motor Skills**, 43: 127-133, 1976.

Marr, D., Early processing of visual information, **Philosophical Transactions of the Royal Society {London}**, B275: 483-524, 1976.

Marshall, J.C., Multiple perspectives on modularity, **Cognition**, 17, 1984.

Marshall, S.P., Sex differences in mathematical errors: an analysis of distractor choices, **Journal for Research in Mathematics Education**, 14: 325-336, 1983.

Masters, B., What makes a monster? **The Sunday Telegraph**, 28/7/91.

Matthews, R., Putting Bounce into Baby, **Daily Telegraph**, 2/9/91.

Mawson, D., Grounds, A., and Tantam, D., Violence and Asperger's Syndrome: A Case Study, **British Journal of Psychiatry**, 147: 566-569, 1985.

Mayer-Kress, G., and Holzfuss, J., Analysis of the Human Electroencephalogram with methods from Nonlinear Dynamics, in L. Rensing, U. Van der Heiden, and M.C. Mackey {eds.}, **Temporal Disorder and Human Oscillatory Systems**, U.S.A.: Springer, 1987.

McFadden,D., and Wightman, F., Audition: Some Relations Between Normal and Pathological Hearing, **Annual Review of Psychology**, 34, pp. 95-128, 1983.

McGinnis, J., Corry, P., and Proctor, P., Amorphous Semiconductor Switching in Melanins, **Science**, 183, pp. 853-855, 1974.

McGlew, Dr T., Seminar Notes, Qualitative Research Course, Faculty of Social Science, Edinburgh University, Spring Term, 1988.

McGourty, C., Homosexuality 'may be due to differences in the brain', **Daily Telegraph**, 30/8/1991.

McKeever, W.F., and Rich, D.A., Left-handedness and immune disorders, **Cortex**, 26, pp. 33-40, 1990.

McManus, I.C., and Bryden, M.P., Geschwind's Theory of Cerebral Lateralisation: Developing a Formal, Causal Model, **Psychological Bulletin**, Vol. 110, No. 2, pp. 237-253, 1991.

Messinger, H.B., Messinger, M.I., and Graham, J.R., Migraine and left-handedness: Is there a connection? **Cephalalgia**, 8, pp. 237-244, 1988.

Metcalfe, J., and Merrill, J., 1987 Conference on Dynamic Patterns in Complex Systems, **Psychobiology**, 16 {1}: 75-78, 1987.

Millodot, M., Do blue-eyed people have more sensitive corneas than brown-eyed people? **Nature**, 255: 151-152, 1975.

Mitchell, F.D., Mathematical Prodigies, **American Journal of Psychology**, 18: 61-143, 1907.

Molenaar, P.C., and Oppenheimer, L., Dynamic Models of Development and the Mechanistic-Organismic Controversy, **New Ideas in Psychology**, 3 {3}: 233-242, 1985.

Molenaar, P.C.M., On the Impossibility of Acquiring More Powerful Structures: A Neglected Alternative, **Human Development**, 29: 245-251, 1986.

Montour, K., William James Sidis, The Broken Twig, **American Psychologist**, April: 265-279, 1977.

Moore, W.H., and Weidner, W.E., Bilateral tachistoscopic word perception in aphasic and normal subjects, **Perceptual and Motor Skills**, 38: 1003-1011, 1974.

Morgan, B.L.G., Effects of Hormonaland other Factors on Growth and Development, Chapter Four in **Brain and Behavioural Development: Interdisciplinary Perspectives on Structure and Function**, U.K.: Surrey University Press/Blackie, 1982.

Morishima, A., Another Van Gogh of Japan: the superior work of a retarded boy, **Exceptional Children**, 41: 92-96, 1974.

Morishima, A., and Brown, L.F., An idiot savant case report: A retrospective view, **Mental Retardation**, 14: 46-47, 1976.

Mountcastle, V.B., An organizing principle for cerebral function: The unit module and the distributed system, in G.M. Edelman and V.B. Mountcastle {eds.}, **The Mindful Brain**, Cambridge, Mass.: MIT Press, 1978.

Nass, R., Baker,S., Speiser, P., Virdis, R., Balsamo, A., Cacciari, E., Loche, A., Dumic, M., and New, M., Hormones and handedness: Left-hand bias in female congenital adrenal hyperplasia patients, **Neurology**, 37, April, pp. 711-715, 1987.

Necka, E., Reaction time and Intelligence, **European Journal for High Ability**, Vol. 1, No. 1/2, 1990.

Neilsen, J., **Agnosia, Apraxia, Aphasia: their Value in Cerebral Localization**, N.Y.: Hoeber, 1946.

Netley, C., and Rovet, J., Relationships among brain organization, maturation rate, and the dvelopment of verbal and non-verbal ability, in S.J. Segalowitz {ed.}, **Language Functions and Brain Organization**, N.Y.: Academic Press, 1983.

Nicolis, J.S., **Dynamics of Hierarchical Systems: an Evolutionary Approach**, U.S.A.: Springer, 1986.

Nurcombe, B., and Parker, N., The Idiot Savant, **Journal of the American Academy**

of Child Psychiatry, 3* 469-487, 1964.

Nyborg, H., Mathematics, sex hormones, and brain function, Peer Commentary, C. Benbow, Sex differences in mathematical reasoning ability...., **Behavioural and Brain Sciences**, 11 {2}: 206-207, 1988.

O'Callaghan, E., Gibson, T., Colohan, H., Walshe, D., Buckley, P., Larkin, C., and Waddington, J., Season of Birth in Schizophrenia: Evidence for Confinement of an Excess of Winter Births to Patients Without a Family History of Mental Disorder, **British Journal of Psychiatry**, 158: 764-769, 1991.

O'Connor, N., and Hermelin, B., Visual and graphic abilities of the idiot-savant artist, **Psychological Medicine**, 17: 81-92, 1987.

O'Connor, N., Intelligence, Handicaps and Talents, **The Mental Retardation and Learning Disability Bulletin**, 15 {2}: 4156, 1987.

O'Connor, N., and Hermelin, B., Visual Memory and Motor Programmes: Their use by Idiot Savant Artists and Controls, **British Journal of Psychology**, 78: 307-323, 1987.

Oppenheim, A.N., **Questionnaire Design and Attitude Measurement**, Heinemann Educational Books, 1966.

Osaka, M., Peak alpha frequency of EEG during a mental task: task difficulty and hemispheric differences, **Psychophysiology**, 21: 101105, 1984.

Oscar-Berman, M., Superior Memory: Perspective from the Neuropsychology of Memory Disorders, in L.K. Obler and D. Fein, **The Exceptional Brain: Neuropsychology of Talent and Special Abilities**, N.Y./London: The Guilford Press, 1988.

O'Sullivan, J., Train spotters "may suffer from autism', **Independent**, 14/9/91.

Owens, W.A., and Grimm, W., A note regarding exceptional musical ability in a low grade imbecile, **Educational Psychology**, 32: 636637, 1941.

Paine, S., **Six Children Draw**, London: Academic Press, 1981.

Pallot, P., Diet clue to North's heart disease rate, **The Times**, 5/9/91.

Parkes, A.S., **Patterns of Sexuality and Reproduction**, London: Oxford University Press, pp. 43-50, 1976.

Patterson, K., and Besner, D., Is the right hemisphere literate? **Cognitive Neuropsychology**, 1: 315-341, 1984.

Payne, S.L.B., **The Art of Asking Questions**, Princeton: Princeton University Press,

1951.

Penfield, W., and Roberts, L., **Speech and Brain Mechanisms**, N.Y.: Atheneum, 1966.

Pennington and Smith, *et al*, Developmental continuities and discontinuties in a form of familial dyslexia, in R.N. Emde and R.J. Harmon {eds.}, **Continuities and Discontinuities in Development**, NY.: Plenum Publications, 123-151, 1984.

Pennington, B.F., Smith, S.D., Kimberling, W.J., Green, P.A., Haith, M.M., Left-handedness and Immune Disorders in Familial Dyslexics, **Archives of Neurology**, Vol. 44, June, 634-639, 1987.

Peterson, J.M., and Lansky, L.M., Left-handedness among architects: some facts and some speculations, **Perceptual and Motor Skills**, 38: 547-550, 1974.

Peterson, J.M., Left-handedness: differences between student artists and scientists, **Perceptual and Motor Skills**, 48: 961-962, 1979.

Peterson, J.M., and Lansky, L.M., Left-handedness among architects: partial replication and some new data, **Perceptual and Motor Skills**, 45: 1216-1218, 1977.

Pettit, J.M., and Noll, J.D., Cerebral dominance and the process of language recovery in aphasia, Presented at the American Speech and Hearing Association, San Fransisco, quoted by Searlman, A., A review of right hemisphere linguistic capabilities, **Psychological Bulletin**, 84: 503-528, 1972.

Phillips, A., Talented Imbeciles, **Psychological Clinic**, 18: 246-255, 1930.

Philpot, M., Rottenstein, M., Burns, A., and Der, G., Season of Birth in Alzheimer's Disease, **British Journal of Psychiatry**, 155: 662-666, 1989.

Piechowski, M.M., Silverman, L.K., and Falk, R.F., Comparison of Intellectually and Artistically Gifted on Five Dimensions of Mental Functioning, **Perceptual and Motor Skills,** 60: 539-549, 1985.

Pollack, R.H., and Silvar, S.D., Magnitude of the Muller-Lyer Illusion in children as a function of pigmentation of the Fundus oculi, **Psychonometric Science**, Vol. 8 {2}, 83-84, 1967.

Pollack, M.H., and Manschreck, T.C., Oculocutaneous Albinism and Schizophrenia, **Biological Psychology**, 21: 830-833, 1986.

Prigogine, I., and Stengers, I., **Order out of Chaos: Man's new dialogue with nature**, London: Flamingo/Fontana, 1985.

Pulver, A.E., Liang, K-Y, Brown, C.H., Wolyniec, P., McCreedy, J., *et al*, Risk Factors in Schizophrenia, Season of Birth, Gender, Family Risk, **British Journal of Psychiatry**, 160, pp. 65-71, 1992.

Rapp, P.E., Zimmerman, I.D., Albano, A.M., Deguzman, G.C., and Greenbaum, N.N., Dynamics of spontaneous neural activity in the simian motor cortex, **Physics Letters**, 110A: 335, 1985.

Ray, W.J., June, K., Turaj, K., and Lundy, R., Dissociative Experiences in a College Age Population: A Factor Analytic Study of Two Dissociation Scales, **Personality and Individual Differences**, Vol. 13, No. 4, pp. 417-424, 1992.

Reed, C., Homosexuals are 'born not made', **The Guardian**, 3/8/1992.

Rees, J., 'Flu is clue to brain illness, **Daily Telegraph**, 3/7/91.

Reeves, P., Scientists find another difference in brains of gays, **Independent**, 3/8/1992.

Rett, A., Uber ein Eigonertiges Hirnatrophisches Syndrom bei Hyperammonamie im Kindersalter, **Wein Med. Wochenschr**., 116, pp. 723-738, 1966.

Richardson, A., and Harris, L.J., Age Trends in Eidetikers, **The Journal of Genetic Psychology**, 147 {3}: 303-308, 1986.

Rife, D.C., and Snyder, L.H., Studies in Human Inheritance VI: A Genetic Refutation of the Principles of "Behaviouristic" Psychology, **Human Biology**, 3: 547-559, 1931.

Rimland, B., Savant capabilities of autistic children and their cognitive implications, in G. Serban {ed.}, **Cognitive Defects in the Development of Mental Illness**, N.Y.: Brunner/Mazell, 1978.

Rimland, B., and Fein, D., Special Talents of Autistic Savants, in L.K. Obler and D. Fein {eds.}, **The Exceptional Brain: Neuropsychology of Talent and Special Abilities**, N.Y./London: The Guilford Press, 1988.

Ritvo, E.R., Freeman, B.J., Scheibel, A.B., Taihung Duong, Robinson, H., Guthrie, D., and Ritvo, A., Lower Purkinje Cell Counts in the Cerebella of Four Autistic Subjects: Initial Findings of the UCLA-NSAC Autopsy Research Report, **American Journal of Psychiatry**, 143 {7}, July: 862-866, 1986.

Roberts, A.D., Case history of a so-called idiot-savant, **Journal of Genetic Psychology**, 66: 259-265, 1945.

Rose, M.R., **Evolutionary Biology of Aging**, U.K.: Oxford University Press, 1991.

Rosenberg, A., and Kagan, J., Iris Pigmentation and Behavioural Inhibition, **Developmental Psychobiology**, 20 {4}: 377-392, 1987.

Rosenberg, A., and Kagan, J., Physical and Physiological Correlates of Behavioural Inhibition, **Developmental Psychobiology**, 22 {8}: 753-770, 1989.

Rosenthal, V., Does it Rattle When You Shake It? Modularity of Mind and the Epistemology of Cognitive Research, in Denes, *et al*, 1988.

Roy, A., Karoum, F., and Pollack, S., Marked Reduction in Indexes of Dopamine Metabolism among Patients with Depression who attempt Suicide, **Archives of General Psychiatry**, Vol. 49, June, 1992.

Rubin, E.J., and Monaghan, S., Calendar Calculation in a Multiple-Handicapped Blind Person, **American Journal of Mental Deficiency**, 70: 478-485, 1965.

Rubin, K.H., and Both, L., Iris Pigmentation and Sociability in Childhood: A Re-Examination, **Developmental Psychobiology**, 22 {7}: 717-725, 1989.

Russell, J., Wagstaff, G.F., Extraversion, Neuroticism and Time of Birth, **British Journal of General Psychiatry**, 22, pp. 27-31, 1983.

Sacchetti, E., Calzeroni, A., Vita, A., Terzi, A., *et al*, The Brain Damage Hypothesis of the Seasonality of borths in Schizophrenia and Major Affective Disorders: Evidence from Computerised Tomography, **British Journal of Psychiatry**, 160, pp. 390-397, 1992.

Sacks, O., The Twins, **The New York Review of Books**, 32, Feb. 28th: 16-20, 1985.

Sacks, O., The Autist Artist, **The New York Review of Books**, 32, April 25th: 17-21, 1985.

Sacks, O., Neurology and the Soul, **The New York Review**, 22, November: 44-50, 1990.

Sacks, O., **Awakenings**, Revised Edition, U.S.A./U.K.: Pan Books, 1990.

Salcedo, J.R., Spiegler, B.J., Gibson, E., *et al*, Note: The autoimmune disease systemic lupus erythematosus is not associated with left-handedness, **Cortex**, 21, pp. 645-647, 1985.

Sanders, B., Mathematical ability, spatial ability, and remedial training, Peer Commentary, C. Benbow, Sex differences in mathematical reasoning ability....., **Behavioural and Brain Science**, 11 {2}: 208-209, 1988.

Sano, F., James Henry Pullen, the Genius of Earlswood, **The Journal of Mental Science**, No. 266, Vol. 64, July, 1918.

Sarton, G., **Six Wings: Men of Science in the Renaissance**, Bloomington, Indiana, Indiana University Press, 1957.

Sass, L.A., Surrealism and Schizophrenia: reflections on Modernism, Repression, and the Schizophrenic Break, **New Ideas in Psychology**, Vol. 8, No. 3, pp. 275-297, 1990.

Satz, P., Miller, E.N., Seines, O., Van Gorp, W., D'Elia, L.F., and Visscher, B., Hand Preference in Homosexual Men, **Cortex**, 27, 1991.

Schacter, S.C., Ransil, B.J., and Geschwind, N., Associations of Handedness with Hair Colour and Learning Disabilities, **Neuropsychologia**, Vol. 25, No. 1b, 269-276, 1987.

Scheerer, M., Rothmann, E., and Goldstein, K., A Case of "Idiot Savant": An Experimental Study of Personality Organization, **Psychological Monographs**, 58 {4}, 1945.

Schmeck, H.M., Brain Abnormalities Cited as Factors in Autism, **Science Times-The New York Times**, Tuesday, June 7th: 19-21, 1988.

Schwartz, D.W., and Karp, S.A., Field dependence in a geriatric population, **Perceptual and Motor Skills**, 24, 495-504, 1967.

Schonberger, A.K., The interrelationship of sex, visual spatial abilities, and mathematical problem solving in grade seven, Doctoral dissertation, University of Wisconsin-Madison, 1976.

Schoon, N., Illness during pregnancy may cause schizophrenia in child, **Independent**, 23/8/90.

Searle, J., **Minds, Brains and Science**, U.S.A./U.K.: Harvard University Press, 1985.

Searleman, A., and Fugagli, A., Suspected autoimmune disorders and left-handedness: evidence from individuals with diabetes, Crohn's disease and ulcerative colitis, **Neuropsychologia**, 25(2), pp. 367-374, 1987.

Searleman, A., Cunningham, T.F., and Goodwin, W., Association Between Familial Sinistrality and Pathological Left-handedness: A Comparison of Mentally Retarded and Nonretarded Subjects, **Journal of Clinical and Experimental Neuropsychology**, Vol. 10, No. 2, pp. 132-138, 1988.

Selfe, L., **Nadia: A Case of Extraordinary Drawing Ability in an Autistic Child**, London: Academic Press, 1977.

Selfe, L., **Normal and Anomalous Representational Drawing Ability in Children**, London: Academic Press, 1983.

Semmes, J., Hemispheric Specialization: A Possible Clue to Mechanism, **Neuropsychologia**, 6: 11-26, 1968.

Shallice, T., Neurological impairment of cognitive processes, **British Medical Bulletin**, 37: 187-192.

Shallice, T., **From Neuropsychology to Mental Structure**, Cambridge/N.Y.: Cambridge University Press, 1988.

Sham, P.C., O'Callaghan, E., Takei, N., Murray, G.K., *et al*, Schizophrenia Following Pre-natal Exposure to Influenza Epidemics between 1939 and 1960, **British Journal of Psychiatry**, 160, pp. 461-466, 1992.

Shenkman, A., Gordon, H.W., and Heifitz, A., Cognitive asymmetries in acute schizophrenics, paper presented at the 8th Annual Meeting of the International Neuropsychological Society, San Francisco, 1980.

Shepherd, R.N., and Metzler, J., Mental rotation of three-dimensional objects, **Science**, 171, pp. 701-703, 1971.

Shur, E., and Hare, E., Age-Prevalence and the Season of Birth Effect in Schizophrenia: A Response to Lewis and Griffin, **Psychological Bulletin**, Vol. 93, No. 2: 373-377, 1983.

Shuter-Dyson, R., and Gabriel, C., **The Psychology of Musical Ability**, London/N.Y.: Methuen, 1981.

Siipola, E.M., and Hayden, S.D., Exploring Eidetic Imagery among the Retarded, **Perceptual and Motor Skills**, 21: 275286, 1965.

Simon, H.A., The architecture of cognition, **Procedures of the American Philosophical Society,** 106: 467-482, 1962.

Singer, W., Neuronal Activity as a Shaping Factor in the Self-Organization of Neuron Assemblies, in Basar, *et al* {eds.}, Springer, 1983.

Skarda, C.A., and Freeman, W.J., How brains make chaos in order to make sense of the world, **Behavioural and Brain Sciences**, 10: 161-195, 1987.

Smith, A., Speech and other functions after left {dominant} hemispherectomy, **Journal of Neurology, Neurosurgery and Psychiatry**, 29: pp. 467-471.

Smith, J., Left-handedness: its association with allergic disease, **Neuropsychologia**, Vol. 25, No. 4, pp. 665-674, 1987.

Sofaer, J.A., and Emery, A.E., Genes for superintelligence? **Journal of Medical Genetics**, 18: 410-413, 1981.

Sperry, R.W., Mental phenomena as causal determinants in brain function, in G. Globus, G. Maxwell, and I. Savodnik {eds.}, **Consciousness and the Brain**, N.Y./London: Plenum, 1976.

Sperry, R., **Science and Moral Priority**, N.Y.: Columbia University Press, 1983.

Spitz, H.H., and LaFontaine, L., The digit span of idiot savants, **American Journal of Mental Deficiency**, 77: 757-759, 1973.

Springer, S.P., and Deutsch, G., **Left Brain, Right Brain**, Third Edition, N.Y.: W.H. Freeman, 1989.

Springett, N.R., and Szulecka Lekarz, T.K., Faculty differences in psychological disturbance among undergraduates on arrival at university, **British Journal of Medical Psychology**, 59: 69-73, 1986.

Stiles-Davis, J., Janowski, J., Engel, M., and Nass, R., Drawing Ability in Four Young Children with Congenital Unilateral Brain Lesions, **Neuropsychologia**.

Stack, S., and Lester, D., Born under a Bad sign? Astrological sign and Suicide Ideation, **Perceptual and Motor Skills**, 66: 461462, 1988.

Stanton, W.R., Feehan, M., Silva, P.A., and Sears, M.R., Note: Handedness and allergic disorders in a New Zealand cohort, **Cortex**, 27, pp. 131-135, 1991.

Steinkamp, S.W., Some characteristics of effective interviewers, **Journal of Applied Psychology**, 50, December, 1966.

Sternberg, S., High-speed scanning in human memory, **Science**, 153: 652-654, 1966.

Stewart, I., **Does God Play Dice: The New Mathematics of Chaos**, London: Penguin, 1989/90

Sudman, S., **Reducing the Cost of Surveys**, Chicago, Aldine Publications, 1967.

Sutton, P.R.N., Association between Colour of the Iris of the eye and Reaction to Dental Pain, **Nature**, Vol. 184, 122, July 11th, 1959.

Tedford, W.H., Hill, W.R., and Hensley, L., Human eye colour and reaction time, **Perceptual and Motor Skills**, 47, 503-506, 1978.

Temple, C.M., Academic discipline, handedness and immune disorders, **Neuropsychologia**, Vol. 28,No. 3, pp. 303-308, 1990.

Terman, L.M., **Genetic Studies of Genius, Vol. I. Mental and Physical traits of a thousand gifted children**, Stanford, CA.: Stanford University Press, 1925.

Thatcher, R.W., Walker, R.A., and Guidice, S., Human Cerebral Hemispheres Develop at Different Rates and Ages, **Science**, 236, May, 1987.

Thomas, G., and Silk, A., **An introduction to the psychology of children's drawings**, U.K.: Harvester Wheatsheaf, 1990.

Thurstone, L.L., and Jeffrey, T.E., **Closure Speed**, Chicago: Industrial Relations Center.

Tikofski, R.S., Kooi, K.A., and Thomas, M.H., Electroencephalographic findings and recovery from aphasia, **Neurology**, 10: 154156, 1960.

Tota, G., and La Marca, F., Correlations between corneal sensitivity and iris colour, **Atti della Fondazione Giorgio Ronchi**, Vol. 37 {1}: 59-69, 1982.

Treffert, D.A., An Unlikely Virtuoso: Leslie Lemke and the Story of the Savant Syndrome, **The Sciences**, New York Academy of Sciences, January/February: 28-35, 1988.

Treffert, D.A., The Idiot-Savant: A Review of the Syndrome, **American Journal of Psychiatry**, 145 {5}: 563-572, 1988.

Treffert, D.A., **Extraordinary People: An Exploration of the Savant Syndrome**, London/N.Y.: Bantam Press, 1989.

Trevor-Roper, P., **The World Through Blunted Sight**, London: Penguin Books, 1988.

Tucker, D.M., and Frederick, S.L., in Chapter Two, Emotion and Brain Lateralization, of H. Wagner and T. Manstead {eds.}, **Handbook of Psychophysiology: Emotion and Social Behaviour**, N.Y.: John Wiley, 1989.

Van Dellen, T., and Geuze, R.H., Motor Response Processing in Clumsy Children, **Journal of Child Psychology and Psychiatry**, 29 {4}: 489-500, 1988.

Viscott, D.S., A Musical Idiot Savant: A Psychodynamic Study, and Some Speculations on the Creative Process, **Psychiatry**, 32: 494515, 1969.

von der Malsburg, C., Modelling Self-Organization and Performance of Neural Nets: How are Nervous Structures Organized? in Basar, et al {eds.}, **Synergetics of the Brain**, Springer, 1983.

Waber, D.P., Sex differences in mental abilities, hemispheric lateralization, and rate of physical growth in adolescence, **Developmental Psychology**, 13, 1977.

Waddington, C.H., **The Strategy of the genes**, Allen and Unwin: London, 1957

Watson, C.G., Tilleskjor, C., Kucula, J., and Jacobs, L., The Birth Seasonality Effect in Schizophrenic Psychiatric Patients, **Journal of Clinical Psychology**, Vol. 40, No. 4, July, 1984.

Weiner, N., **Ex-Prodigy: My childhood and youth**, N.Y.: Simon and Schuster,

1953.

Wexler, B.E., Mason, J.W., and Giller, E.L., Possible Subtypes of Affective Disorder Suggested by Differences in Cerebral Laterality and Testosterone: A Preliminary Report, **Archives of General Psychiatry**, Vol. 46, May, pp. 429-433, 1989.

White, P.A., The structured Representation of Information in Long-Term Memory: A Possible Explanation for the accomplishments of "Idiots Savants", **New Ideas in Psychology**, 6 {1}: 3-14, 1988.

Williams, N., Brain speed link to "intelligence", **The Guardian**, 19/2/91.

Wing, L., Asperger's Syndrome: a clinical account, **Psychological Medicine**, 11: 115-129, 1981.

Winner, E., **Invented Worlds: The Psychology of the Arts**, Boston, Mass.: Harvard University Press, 1982.

Wittig, M.A., and Peterson, A.L. {eds.}, **Sex Related Differences in Cognitive Function**, Academic Press, 1979.

Wolf-Klein, G.P., Silverstone, F.A., Brod, M.S., *et al*, Are Alzheimer patients healthier? **Journal of the American Geriatrics Society**, 36: 219-224, 1988.

Woodward, S.H., An anatomical model of hemispheric asymmetry, **Journal of Clinical and Experimental Neuropsychology**, 10: 68, 1988.

Worthy, M., **Eye Colour, Sex and Race: Keys to Human and Animal Behaviour**, U.S.A.: Droke House/Hallux, 1974.

Zaidel, E., Linguistic competence and related functions in the right hemisphere of man following cerebral commissurotomy and hemispherectomy, Doctoral dissertation, California Institute of Technology, 1973.

Zaidel, D.W., and Kasher, A., Hemispheric memory for surrealistic versus realistic paintings, **Cortex**, 25: 617-641, 1989.

Zaidel, D.W., Personal communication, 1989.

Zangwill, O., Speech and the minor hemisphere, **Acta Neurologica Psychiatrica**, 67: 1013-1020.